PB90-178302

Communicating Radon Risk Effectively: A Mid-Course Evaluation

(U.S.) Environmental Protection Agency, Washington, DC

Jul 87

U.S. Department of Commerce
National Technical Information Service
NTIS

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. EPA-230-07-87-029	2.	3. Recipient's Accession No PB90 178302/AS

4. Title and Subtitle
Communicating Radon Risk Effectively: A Mid-Course Evaluation

5. Report Date
July 1987

6.

7. Author(s)
F. Reed Johnson
V. Kerry Smith, William H. Desvousges, Ann Fisher, ^

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
Research Triangle Institute
P.O. Box 12194
Research Triangle Park, NC 27709

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G) Cooperative Agreement No. CR-811075

12. Sponsoring Organization Name and Address
Office of Policy, Planning and Evaluation
Risk Communication Program
U.S. Environmental Protection Agency
Washington, DC 20460

13. Type of Report & Period Covered
Interim

14.

15. Supplementary Notes

Additional data to be collected through 1989

16. Abstract (Limit: 200 words)

A panel of 2300 homeowners was divided into subgroups to test the effectiveness of six alternative ways of explaining the risk from naturally occuring radon gas. The research design focused on two dimensions: Qualitative vs. quantitative and directive vs. evaluative. These characteristics led to 4 experimental booklets, which were compared with EPA's Citizen's Guide and a one-page fact sheet. The evaluation examined (1) how much people learned about radon, (2) whether they could form risk perceptions consistent with their home's measured radon level, and (3) whether they felt they had enough information to make a decision about mitigation. The fact sheet did not perform well on any of these evaluation criteria. None of the five booklets clearly was best for all 3 evaluation criteria; the report discusses the implications for designing an effective radon risk communication program.

17. Document Analysis a. Descriptors

Radon Risk Communication
Evaluation
Survey of effectiveness

b. Identifiers/Open-Ended Terms

Survey research design when repondents are at risk
Panel surveys
Comparison survey groups

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
No restriction on distribution. Available from NTIS, Springfield, VA 22161	unclassified	244
	20. Security Class (This Page)	22. Price
	unclassified	

(See ANSI-Z39.18) See Instructions on Reverse

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce

EPA-230-07-87-029

PB 90-178302

Communicating Radon Risk Effectively: A Mid-Course Evaluation

Prepared by

V. Kerry Smith
Vanderbilt University and
North Carolina State University

William H. Desvousges
Research Triangle Institute

Ann Fisher
F. Reed Johnson
U.S. Environmental Protection Agency

EPA Cooperative Agreement No. CR-811075

July 1987

REPRODUCED BY
U.S. DEPARTMENT OF COMMERCE
NATIONAL TECHNICAL INFORMATION SERVICE
SPRINGFIELD, VA. 22161

Vanderbilt
University

RTI
Research Triangle
Institute

EPA
U.S. Environmental
Protection Agency

Communicating Radon Risk Effectively: A Mid-Course Evaluation

Prepared for

Office of Policy Analysis
U.S. Environmental Protection Agency
Washington, DC 20460

Ann Fisher, Project Officer

Prepared by

V. Kerry Smith
Vanderbilt University
Nashville, TN 37235
and
North Carolina State University
Raleigh, NC 27650

William H. Desvousges
Research Triangle Institute
Research Triangle Park, NC 27709

Ann Fisher
F. Reed Johnson
U.S. Environmental Protection Agency
Office of Policy Analysis
Washington, DC 20460

July 1987

The information in this document has been funded wholly or in part by the United States Environmental Protection Agency under Cooperative Agreement No. CR-811075. It has been subject to the Agency's peer and administrative review, and it has been approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

EXECUTIVE SUMMARY

The U.S. Environmental Protection Agency (EPA) has become increasingly concerned about the risks people face from radon gas in their homes. EPA has developed a risk communication program to help people evaluate their risks and decide whether mitigation is necessary. EPA's Office of Policy Analysis sponsored this Cooperative Agreement research to address radon risk communication research issues. This report provides a mid-course evaluation of the effectiveness of the New York State Energy Research and Development Authority's (NYSERDA's) risk communication program, which is conducting an independent study to monitor radon exposures in New York State.

Research Design

The research addresses two main risk communication issues: the use of qualitative-versus-quantitative information to explain risk and the use of command-versus-cajole tone to describe the need for further actions about radon. The quantitative-versus-qualitative feature of the design is straightforward: Does numerical risk information help people form risk perceptions and make subsequent decisions? The command-versus-cajole feature distinguishes between information presented in a directive-versus-evaluative format. The cajole tone encourages individuals to use the information in forming independent judgment about their personal risk, based on their own circumstances, and to determine whether further actions are needed. The directive approach, or command tone, emphasizes an expert's (i.e., EPA's) evaluation of what is the appropriate level for action.

The appraisal uses a unique research design: a panel of 2,300 New York State homeowners participating in NYSERDA's radon monitoring study. These homeowners are facing real risks, not participating in a hypothetical experiment. A comparison sample of 252 homeowners not in the measurement study also is included. The design evolved from a long process that included focus groups and expert reviews. It includes four experimental brochures developed as part of the research, EPA's *Citizen's Guide to Radon*, and a brief fact sheet. The information materials were randomly assigned to homeowners. To date, almost 5,000 telephone interviews have been completed with response rates exceeding 90 percent for the homeowners in the measurement study. The socioeconomic characteristics of the homeowners in both the monitored and comparison samples are very similar.

The evaluation considers four indicators of effectiveness: learning about radon risks, measurement, and mitigation; the formation of subjective risk perceptions; the demand for radon information; and homeowners' decisions to mitigate their radon levels. Because the homeowners participating in the study would not be expected to make mitigation decisions now, our evaluation is a mid-course appraisal that considers the first three indicators of effectiveness. This appraisal addresses the question raised by former EPA Assistant Administrator Milton Russell: "Do the right people worry and the others stop?"

Learning

The first indicator of effectiveness is whether people learned from the information materials. All the brochures improved learning relative to the fact sheet. Homeowners knew most about how to measure radon, with 91 percent answering questions on this topic correctly. They answered 63 percent of the risk questions correctly, but only 38 percent could answer a difficult mitigation question. The cajole/qualitative brochure containing a chart with three colored columns to distinguish between lifetime and annual risks enabled 83 percent of the homeowners receiving it to understand the distinction. Our statistical analysis showed people with higher levels of education, awareness, and radon had higher learning, while older people had lower learning.

Risk Perception Formation

The second indicator of effectiveness is whether people form rational risk perceptions. Unlike other recent studies that found no simple association between perceived and technical risks, our results show people's perceptions generally change in the appropriate direction in response to information on radon risks. After receiving their radon readings and information treatments, 47 percent of the homeowners perceived their risk to be on the low end of our scale, an increase of 25 percent over the baseline survey findings. The percentage of homeowners who did not know how serious their risks were in the baseline survey decreased from about 25 percent to less than 5 percent in the followup survey. The statewide average (geometric mean) radon level for New York is less than 1 picocurie per liter of air.

The direction of change is consistent with rationality, but the adjustments are far from perfect. Some groups have more difficulty assessing their risks from radon. Older people and less educated people were less likely to process risk information correctly. The same was true for homeowners who received only the fact sheet about radon.

Homeowners had difficulty processing the information in the charts used to communicate risk. Compared with homeowners who have low radon levels, those with higher radon levels were more likely to mistate the placement of their radon reading. Those receiving the EPA *Citizen's Guide* also were more likely to incorrectly mistate their reading placement. These results are preliminary because our analysis has not distinguished whether the reported values were overstated or understated. We have not analyzed whether the mistatements may have been caused because people adjusted their risks.

Information Demand

We assume that lower demands for additional information are preferred to higher ones. Demands beyond the printed materials could severely strain an agency's risk communication resources. To evaluate the demand for more information, we asked homeowners about their willingness to purchase the services of a radon diagnostician—a certified inspector who would diagnose their radon problem. The estimated willingness to pay for purchasers ranged from $75 to $170 while those for nonpurchasers ranged from $45 to $125. The model estimates were remarkably stable and robust across alternative specifications. The results showed the intent to purchase the service declining as the offer price increased, which is consistent with economic theory. Despite low risks, people who received only the fact sheet were significantly more willing to demand the services of a radon diagnostician than those receiving any of the five brochures. They also were more likely to ask for more information on risk and on mitigation.

Our findings indicate that people use informal communication channels more than formal ones to find out more about radon. When they discussed their radon results, it was more likely to be with family members, friends, relatives, and neighbors. Less than 1 percent of the homeowners contacted a government agency or public official after receiving their radon readings and information materials. This implies that the NYSERDA information program effectively reduced the need for more information from government sources. Nevertheless, homeowners in New York are not likely to know which agencies to turn to for more information about radon. Less than 8 percent would have turned to the right agency.

Implications

Several important implications can be drawn from this mid-course evaluation of the NYSERDA risk communication program. First, the treatments caused important differences in objective measures of learning, risk perception, and information demand. However, most respondents thought their own information treatment was useful and understandable, even those receiving the fact sheet. This implies that information program evaluation must employ perceptual/behavioral measures of performance. Simply asking people whether they liked risk communication materials can be misleading.

Second, regardless of how effectiveness was measured, the brochures out-performed the fact sheet. Even though the homeowners themselves found the fact sheet useful, our evaluation showed lower levels of learning, higher demands for more information, and higher levels of anxiety.

The fact sheet was similar to ones used in other states and had better communication features than most of the radon risk information provided by the private sector. Our findings clearly show the need for, and potential value of, EPA's risk communication efforts such as the *Citizen's Guide* and other new risk communication initiatives. Difficulties people experienced in using the charts in the *Citizen's Guide* imply that there is room for improvement in these efforts as well. Nonetheless, better risk communication can help the right people worry and the others stop.

Third, our findings imply that several factors improved the effectiveness of risk communication. The cajole/qualitative brochure helped homeowners develop a more intuitive understanding of their risk, shown by their higher learning, and a better ability to advise their neighbors about radon risks. The quantitative brochures, containing numerical risk information, were most effective in reducing divergence between perceived and technical risk. The EPA *Citizen's Guide*, containing the most information, and the quantitative versions lead to the greatest reduction in the demand for more information.

Fourth, none of the risk communication channels we have evaluated seems to work well for older people. Even after adjusting for differences in education and radon awareness and other factors, older people showed less learning and had more difficulty forming their risk perceptions. They also were less likely to intend to purchase the services of a radon diagnostician and less likely to use additional information brochures on either radon risks or mitigation. Because older people experienced problems in evaluting their risks, it is important to determine whether their responses are rational given their circumstances, or reflect the need to find a more effective source for communicating risk information.

Fifth, our mid-course appraisal shows that homeowners did respond to the risk information rationally. People with higher radon readings perceived their risks to be more serious than those with lower readings. However, our results also show that we need to improve our understanding of the relationship between perceived and technical risk estimates.

In the next stages of this study, it also will be possible to track homeowners' mitigation decisions, which are needed to evaluate our fourth effectiveness indicator. This evaluation cannot be completed until after the annual radon readings are sent to the homeowners. An evaluation of alternative communication channels can also occur then.

CONTENTS

Chapter Page

Executive Summary iii
Figures ix
Tables xi

1 COMMUNICATING RADON RISK EFFECTIVELY: AN INTRODUCTION 1-1
1.1 Background 1-1
1.2 Radon Regulatory Issues 1-2
1.3 Research Overview 1-3
1.4 Research Objectives 1-9
1.5 Guide to the Report 1-10
1.6 References 1-10

2 COMMUNICATING RADON RISK EFFECTIVELY: RESEARCH DESIGN AND IMPLEMENTATION 2-1
2.1 Introduction 2-1
2.2 Developing the Research Design 2-2
2.3 Research Design 2-6
2.4 Experimental Design 2-9
2.5 Measuring the Effectiveness of a Risk Information Program 2-13
2.6 Survey Sampling 2-16
2.7 Survey Data Collection 2-17
2.8 Homeowner Profile 2-17
2.9 Implications 2-21
2.10 References 2-21

3 INFORMATION AND LEARNING 3-1
3.1 Introduction 3-1
3.2 Radon Information and Aggregate Learning 3-1
3.3 Repeated Questions and Learning 3-11
3.4 Conclusions 3-17
3.5 References 3-19

4 THE EFFECTS OF INFORMATION ON RADON RISK PERCEPTIONS 4-1
4.1 Introduction 4-1
4.2 Changes in the Distribution of Perceived Risks 4-1
4.3 Homeowners' Use of the Information Brochures 4-6
4.4 A Behavioral Model for Radon Risk Perceptions 4-14
4.5 More Evidence on the Plausibility of Households' Subjective Radon Risks 4-20
4.6 Conclusions 4-24
4.7 References 4-26

CONTENTS (continued)

Chapter Page

5 THE DEMAND FOR RADON INFORMATION 5-1
  5.1 Introduction 5-1
  5.2 Radon Information Delivery Model 5-1
  5.3 Willingness to Pay for Radon Information 5-5
  5.4 Radon Communication Channels 5-15
  5.5 Conclusions 5-24
  5.6 References 5-26

6 THE OVERALL EFFECTIVENESS OF THE NYSERDA RISK COMMUNICATION PROGRAM AND FUTURE RESEARCH ISSUES 6-1
  6.1 Introduction 6-1
  6.2 Consistency Between Perceived and Technical Risk Estimates 6-2
    6.2.1 Comparison 1: Perceived Risk Messages and Technical Risks 6-3
    6.2.2 Comparison 2: Posterior Risk Perceptions and Technical Risks 6-4
  6.3 Brochure Evaluation: Overall Assessment 6-7
    6.3.1 Learning 6-9
    6.3.2 Risk Perceptions 6-10
    6.3.3 Demand for More Information 6-10
    6.3.4 Summary 6-10
  6.4 Future Research 6-11
    6.4.1 The Annual Readings and Followup Survey 6-11
    6.4.2 The Comparison Sample 6-11
    6.4.3 Forming Risk Perceptions 6-11
    6.4.4 Targeted Risk Communication 6-11
    6.4.5 Refinement in Technique and Conceptual Modeling 6-12
    6.4.6 Alternative Communication Channels 6-12
  6.5 Implications 6-12
  6.6 References 6-13

Appendixes

A Radon Measurements and Research Design A-1

B Design Implementation B-1

C Sample Design and Allocation and Sample Size Justification ... C-1

D Questionnaires D-1

FIGURES

Number Page

1-1 Radon risk charts 1-5
1-2 Major differences in brochure tone 1-7
1-3 Overview of radon information study 1-8

2-1 Time sequence of activities 2-10
2-2 Experimental design alternative information delivery vehicles 2-12
2-3 Radon risk information--experimental design 2-14

3-1 Skin problems versus lung cancer 3-13
3-2 Differences in radon measurements 3-13
3-3 Comparisons of radon concentration 3-14
3-4 Mitigation question results 3-14

4-1 "The risk from one year of exposure to radon is much lower than the risk from lifetime exposure" 4-7
4-2 Frequency distributions for correct use of risk charts 4-9

5-1 Where would New York homeowners turn for radon information? 5-15
5-2 Sources of additional radon information used 5-17
5-3 People with whom New York homeowners discussed their radon readings 5-18
5-4 Alternative delivery vehicles for additional radon information 5-19
5-5 Alternative delivery vehicles for additional radon information by version 5-21
5-6 Preferences for communication channels by radon reading 5-22

6-1 Homeowners' brochure evaluation 6-8
6-2 Overall brochure evaluation 6-9

TABLES

Number		Page
2-1	Activities Involving Psychologists, Communication Specialists, Decision Scientists, and Market Researchers in Vanderbilt-RTI Cooperative Agreement	2-5
2-2	Readability Grade Levels	2-8
2-3	Weighted Summary Statistics (pCi/L) for the New York State Radon Study, Overall and by Geographic Strata	2-18
2-4	Baseline and Followup Surveys--Frequencies and Relative Frequencies of Final Interview Results for NYSERDA Homeowners	2-19
2-5	Comparison Group Homeowners: Final Interview Status, Baseline and Followup	2-19
2-6	Socioeconomic Characteristics of Survey Samples	2-20
3-1	Radon Quiz Questions	3-2
3-2	Percent Correct by Class of Question	3-5
3-3	Description of Socioeconomic, Attitudinal, and Technical Variables	3-7
3-4	Total Correct Responses with Followup Radon Quiz: Poisson Regression Models	3-8
3-5	Multinomial Logit Models for Questions Repeated on Baseline and Followup Surveys	3-16
3-6	Revised Multinomial Logit Models--Alternative Treatment of Age Variable	3-18
4-1	Frequency Distributions for Perceived Risk by Sources of Risk: Baseline vs. Followup Surveys	4-3
4-2	Frequency Distributions for Personal Risk from Radon by Information Treatment: Baseline vs. Followup Surveys	4-5
4-3	Definitions of Correct Use of Risk Charts	4-9
4-4	Description of Socioeconomic, Attitudinal, and Technical Variables	4-10
4-5	Determinants of Ability to Use Risk Charts: Probit Models	4-11
4-6	Probit Models for Correct Use of Risk Charts	4-14
4-7	Radon Risk Perception Models	4-17
4-8	Definition of Appropriate Time Schedule for Mitigation in Advice to Neighbor	4-22
4-9	Probit Results on Homeowners' Recommendations to Neighbors	4-23

TABLES (continued)

Number		Page
5-1	Description of Socioeconomic, Attitudinal, and Technical Variables	5-6
5-2	Probit Estimates for Decision to Purchase Services of Radon Diagnostician	5-8
5-3	Willingness-to-Pay Estimates for Radon Information Agent: Means by Design Point for Purchasers	5-11
5-4	Willingness-to-Pay Estimates for Radon Information Agent: Means by Design Point for Nonpurchasers	5-12
5-5	Willingness-to-Pay Estimates for Radon Information Agent: Means by Age Class for Purchasers	5-13
5-6	Willingness-to-Pay Estimates for Radon Information Agent: Means by Age Class for Nonpurchasers	5-13
5-7	Who is Likely to Use Longer Brochures: Probit Results	5-23
6-1	Sample vs. Technical Risks from Radon	6-4
6-2	Subjective vs. Technical Risks from Radon	6-6

CHAPTER 1

COMMUNICATING RADON RISK EFFECTIVELY: AN INTRODUCTION

1.1 BACKGROUND

Radon gas can be a serious health hazard. It was originally recognized as a problem in Sweden and Canada and, to a more limited extent, in Maine and Florida in the United States. Over the past 2 years, the public's concern about radon risks has increased throughout the United States and Europe. In Norway and Sweden, new epidemiological studies soon will improve the available estimates of the risks people face in their homes, and researchers are continuing their investigations of ways to reduce radon concentrations. The British are concerned that radon is a leading cause of lung cancer in England, perhaps second after smoking (Pearce [1987]).

In the United States, concern about radon increased substantially among the public and health experts when very high radon concentrations were discovered 3 years ago in the Reading Prong. Beginning near Reading in Southeastern Pennsylvania, this geological formation extends through parts of Pennsylvania, New Jersey, New York, and to a lesser extent Connecticut. Earlier mining activities had revealed high radon concentrations in Florida, Montana, Colorado, and other parts of the Western United States. High radon levels are continually being discovered in other parts of the country as well. For example, Tennessee officials have found elevated radon concentrations in the Nashville area. The same is true of areas in Northern Virginia and Maryland (Gerusky [1987], Lowry [1986], and Yepsen [1987]). Experts disagree over the exact magnitude of the risks involved, but most agree that radon is the most serious indoor air pollutant, and that high concentrations represent a significant health hazard (Coyle and Drachler [1986] and Wlazelk [1986]).

The National Academy of Sciences recently convened a workshop on Indoor Radon. An informal summary of its recommendations emphasized the importance of information programs in reducing radon exposures. It noted the need for households to take action about radon in their homes and suggested that merely providing scientific information is unlikely to stimulate these actions. The participants questioned how much policymakers should intervene in private lives to protect people from radon exposure. They also called for a cohesive program of research that would address the difficulties people have in responding to scientific information.

Our research addresses these radon risk communication issues. A preliminary analysis of 2,300 New York State homeowners facing actual risks suggests that properly designed information programs do transfer knowledge about radon risks and lead to systematic changes in risk perceptions.

1.2 RADON REGULATORY ISSUES

Environmental Protection Agency (EPA) Administrator Lee Thomas has made radon a main target of the Agency's efforts to manage environmental risks. Radon's physical characteristics, however, complicate the development of an effective policy to manage its risks. Because radon occurs naturally from the underlying rocks and soil, there is no villain to serve as a focal point for people's reactions. In a focus group to evaluate early versions of EPA's communication materials, one participant remarked: "What are we going to do, sue God?" (Desvousges and Kollander [1986]). Sandman [1987] suggests that the lack of a well-defined bad guy causes people to have less outrage about the risks from radon exposure, making it more difficult to motivate them to test their homes for radon. Former EPA Assistant Administrator Milton Russell [1986] noted that the government will spend over $300 million to reduce radon exposure from uranium tailings from former commercial operations and only a fraction of that amount on programs to reduce the risk from naturally occurring radon exposure. If current policies accurately reflect voter sentiments, then the differences in the average household's perception of the property rights to safety in these two situations may partially explain the differences in spending (see Smith and Desvousges [1986, 1987]).

Because radon occurs naturally and people experience its risks primarily in their homes (or buildings), EPA's conventional regulatory approaches are unlikely to be appropriate. The Office of Radiation Programs is in charge of implementing EPA's radon policy. Its Director, Richard Guimond, has described the Agency's role as facilitating the flow of information about radon. (See Coyle and Drachler [1986].) EPA's efforts include providing information and technical assistance to the States, setting guidelines to assist homeowners in determining whether mitigation actions are needed, and conducting engineering research to find ways for effectively reducing the radon concentrations in homes.

In contrast with direct regulation, an information-based approach requires that individual property owners ultimately decide when and how to reduce their risks. Such an approach differs significantly from the majority of EPA's policy efforts, which usually set maximum emission levels from some type of pollution source. This suggests a clear need to evaluate how the design of an information program affects its performance in communicating risk information and in motivating households to undertake mitigation actions. The success of EPA's efforts to communicate these risks will influence the effectiveness of the Agency's overall policies for managing radon risks.

There are, however, many challenges facing an information program as a policy instrument to reduce the public health risks faced by households from radon. Adler and Pittle [1984] conclude that communication/education programs have been largely ineffective in inducing individuals to cut back on cholesterol intake or change other behavior patterns. In contrast, Viscusi, Magat, and Huber [1986] are optimistic that warning labels can help households to understand the risks of such hazardous consumer products as chlorine bleach and drain cleaners. However, their research design elicits people's intentions of taking precautions in the use of products with varying risk labels rather than actual behavior.

Kasperson and Palmlund [1987] point out that the scope of a risk communication program is extensive. It ranges from practical elements--e.g., how to best present risk information, or what communication channels to use--to ethical ones--e.g., the motives of the Agency. Risk communication also exceeds the boundaries of traditional disciplinary research.

In a speech to the Columbia School of Journalism, former EPA Assistant Administrator Milton Russell [1986] summed up both the importance and complexity of effective risk communication:

> Real people are suffering and dying because they don't know when to worry, and when to calm down. They don't know when to demand action to reduce risk and when to relax . . . . There is only so much individuals can worry about. There is only so much society can do. The key is to choose the right worries and the right actions. We don't do that very well when it comes to the environment. [pp. 1-2]

1.3 RESEARCH OVERVIEW

This report presents preliminary results of a research project that involves the cooperative efforts of the New York State Energy Resarch and Development Authority (NYSERDA), the New York State Department of Health, the U.S. Environmental Protection Agency (EPA), and the researchers participating in a cooperative agreement with EPA (CR-811075). The risk communication research complements a NYSERDA project that is estimating the average concentrations of radon in homes throughout New York State. To develop these estimates, NYSERDA is monitoring the indoor radon levels for a scientifically designed sample of about 2,300 homeowners. The NYSERDA project design includes sending each participating homeowner the monitor results for his house.

However, it was not clear what information households would need to evaluate their radon readings and how to present that information. NYSERDA was concerned about how to motivate the households involved to take appropriate remedial actions but not create undue anxiety. Its need for an evaluation of how to communicate radon risk has provided EPA with an opportunity to evaluate the effectiveness of risk communication in reducing the risks, and anxiety, from radon exposure. Our research was designed to address the needs of both NYSERDA and EPA.

Our experimental design randomly assigns carefully structured radon information materials to each homeowner. Although each set of materials includes about the same information, some parts differ in systematic ways. The differences were based on recommendations from a panel of experts who were asked what the most important unanswered questions are in communicating risks such as that from radon exposure.

Figure 1-1 shows the differences between quantitative and qualitative formats for communicating risks. This part of the design addresses whether expressing risk numerically helps people evaluate the severity of their exposure to radon. As we discuss in Chapter 2, experts disagree over the answer to this question.

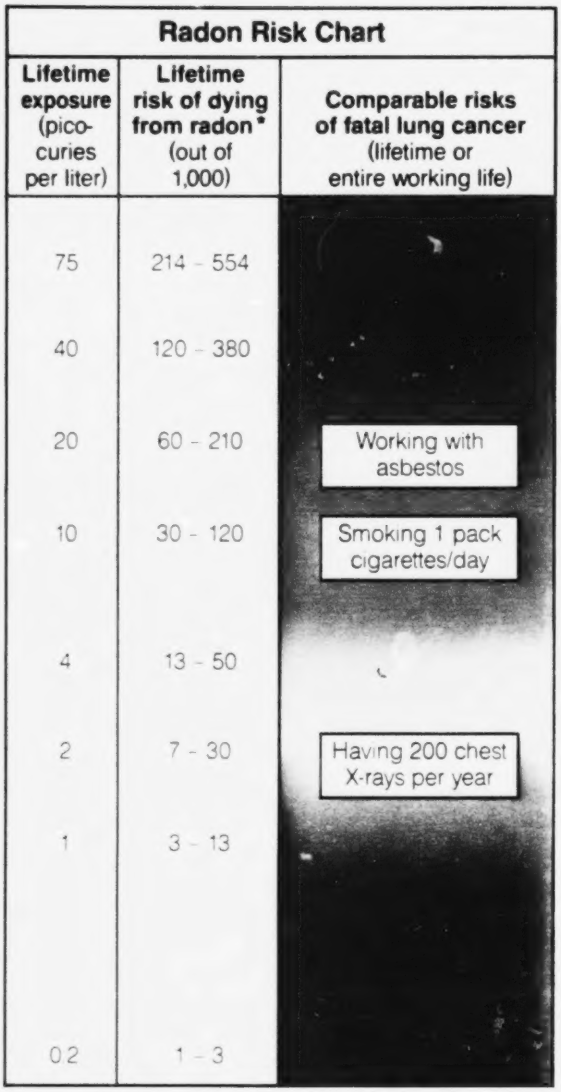
The other major question addressed in our design is whether the tone used in a communication brochure affects people's perceived risks or subsequent actions. We compare a directive or "command" tone, based largely on EPA's action guidelines, with an evaluative or "cajole" tone. Figure 1-2 illustrates how the differences in tone were reflected in the brochures, especially the statements about lifetime risk. Our design allows for each of these elements--qualitative, quantitative, command, and cajole--to be evaluated independently as well as together. We also evaluate the EPA *Citizen's Guide* and a fact sheet used earlier by the State of New York (and similar to fact sheets used in other states).

The design also recognizes that this is not a hypothetical experiment for the homeowners participating in NYSERDA's measurement study. Exposures to radon are the source of real risks. This means we must balance the needs of all three groups--NYSERDA, EPA, and the homeowners. In fairness to the participating homeowners, each brochure contained the same information on the nature of radon, its health effects, the risks associated with various lengths of exposure, and mitigation alternatives. Although the fact sheet has less information on risk, it included the EPA guidelines and those of the National Council on Radiation Protection. Also, it was sent only to homeowners with less than 1 picocurie of radon per liter of air in their homes.

Figure 1-3 provides an overview of how the radon information study combines policy and research activities to evaluate the effectiveness of risk communication. The need for careful timing and coordination in the research activities is apparent. The first block in Figure 1-3 highlights the survey that we conducted to obtain baseline data on perceived risks from radon exposure. This survey also acquired other baseline information on homeowners' knowledge and awareness about radon and preferred channels for communicating risk information. After the information materials (including the readings) were sent to the homeowners, we followed up on the same issues in a second survey.

The second block in Figure 1-3 highlights the information materials used in helping New York State inform households about their risks from radon. These materials explain radon measurements, risks, and mitigation alternatives. The third block indicates the key features in our design of the radon risk information formats. The fourth block shows alternative ways of delivering information to the households. These include mailings, town meetings, and radon audits. Only the results from mailings are reflected in this report, but we have acquired information on the preferences for other delivery vehicles and communication channels. The fifth block represents the 2,300 households participating in the NYSERDA study that received the alternative brochure or fact sheet. The NYSERDA study also calls for annual radon readings to be sent to the homeowners in the summer of 1987, providing another opportunity for us to evaluate risk communication.

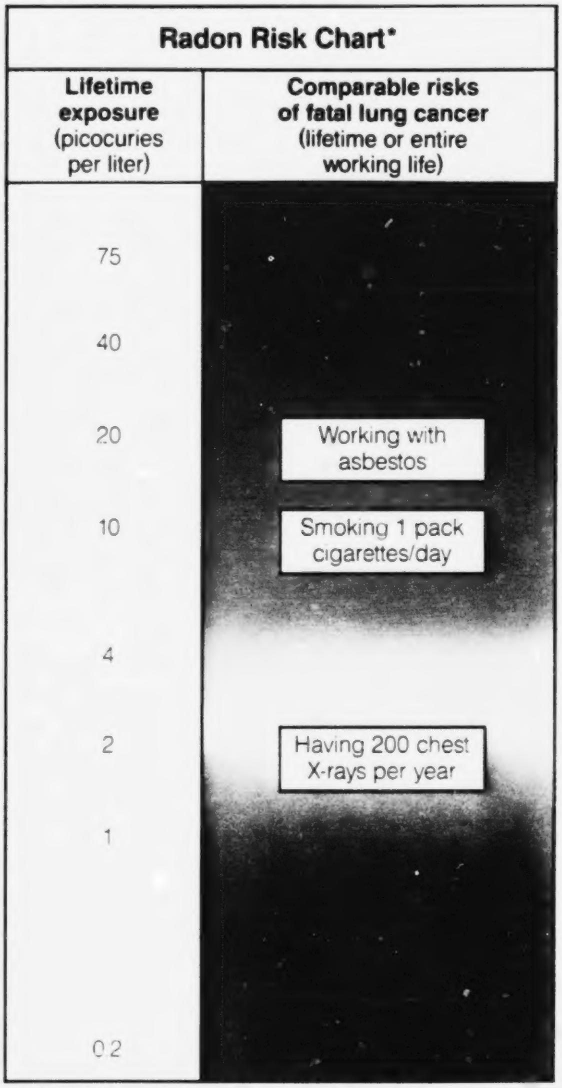
Quantitative



Radon Risk Chart		
Lifetime exposure (picocuries per liter)	**Lifetime risk of dying from radon*** (out of 1,000)	**Comparable risks of fatal lung cancer** (lifetime or entire working life)
75	214 - 554	
40	120 - 380	
20	60 - 210	Working with asbestos
10	30 - 120	Smoking 1 pack cigarettes/day
4	13 - 50	
2	7 - 30	Having 200 chest X-rays per year
1	3 - 13	
0.2	1 - 3	

*U.S. Environmental Protection Agency lifetime risk estimates. The National Council on Radiation Protection has estimated lower risk, but it still considers radon a serious health concern.

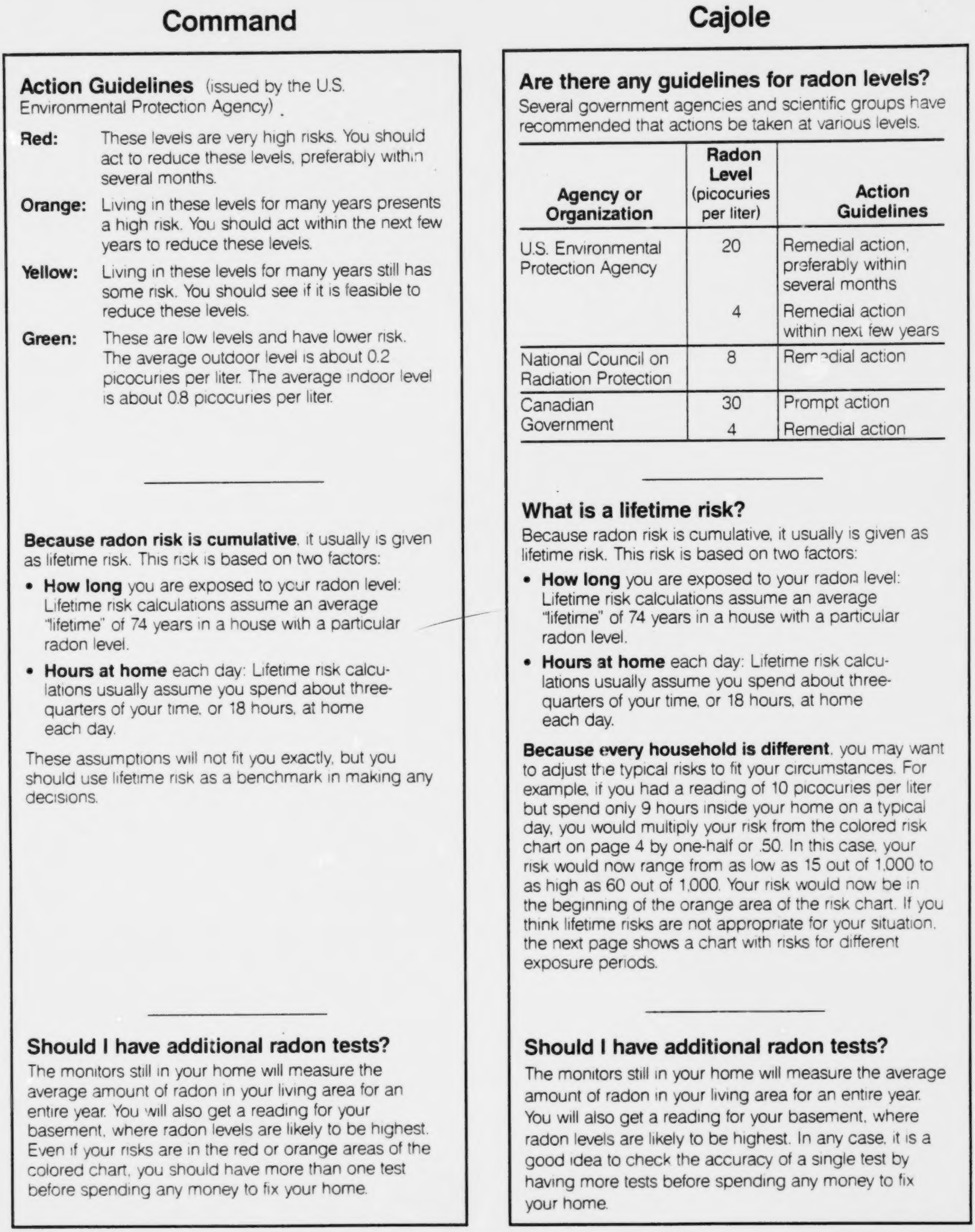
Qualitative



Radon Risk Chart*	
Lifetime exposure (picocuries per liter)	**Comparable risks of fatal lung cancer** (lifetime or entire working life)
75	
40	
20	Working with asbestos
10	Smoking 1 pack cigarettes/day
4	
2	Having 200 chest X-rays per year
1	
0.2	

*Colors are based on U.S. Environmental Protection Agency lifetime risk estimates. The National Council on Radiation Protection has estimated lower risk, but it still considers radon a serious health concern.

Figure 1-1. Radon risk charts.



Command

Action Guidelines (issued by the U.S. Environmental Protection Agency)

Red:	These levels are very high risks. You should act to reduce these levels, preferably within several months.
Orange:	Living in these levels for many years presents a high risk. You should act within the next few years to reduce these levels.
Yellow:	Living in these levels for many years still has some risk. You should see if it is feasible to reduce these levels.
Green:	These are low levels and have lower risk. The average outdoor level is about 0.2 picocuries per liter. The average indoor level is about 0.8 picocuries per liter.

Because radon risk is cumulative, it usually is given as lifetime risk. This risk is based on two factors:

- **How long** you are exposed to your radon level: Lifetime risk calculations assume an average "lifetime" of 74 years in a house with a particular radon level.
- **Hours at home** each day: Lifetime risk calculations usually assume you spend about three-quarters of your time, or 18 hours, at home each day.

These assumptions will not fit you exactly, but you should use lifetime risk as a benchmark in making any decisions.

Should I have additional radon tests?

The monitors still in your home will measure the average amount of radon in your living area for an entire year. You will also get a reading for your basement, where radon levels are likely to be highest. Even if your risks are in the red or orange areas of the colored chart, you should have more than one test before spending any money to fix your home.

Cajole

Are there any guidelines for radon levels?

Several government agencies and scientific groups have recommended that actions be taken at various levels.

Agency or Organization	Radon Level (picocuries per liter)	Action Guidelines
U.S. Environmental Protection Agency	20	Remedial action, preferably within several months
	4	Remedial action within next few years
National Council on Radiation Protection	8	Remedial action
Canadian Government	30	Prompt action
	4	Remedial action

What is a lifetime risk?

Because radon risk is cumulative, it usually is given as lifetime risk. This risk is based on two factors:

- **How long** you are exposed to your radon level: Lifetime risk calculations assume an average "lifetime" of 74 years in a house with a particular radon level.
- **Hours at home** each day: Lifetime risk calculations usually assume you spend about three-quarters of your time, or 18 hours, at home each day.

Because every household is different, you may want to adjust the typical risks to fit your circumstances. For example, if you had a reading of 10 picocuries per liter but spend only 9 hours inside your home on a typical day, you would multiply your risk from the colored risk chart on page 4 by one-half or .50. In this case, your risk would now range from as low as 15 out of 1,000 to as high as 60 out of 1,000. Your risk would now be in the beginning of the orange area of the risk chart. If you think lifetime risks are not appropriate for your situation, the next page shows a chart with risks for different exposure periods.

Should I have additional radon tests?

The monitors still in your home will measure the average amount of radon in your living area for an entire year. You will also get a reading for your basement, where radon levels are likely to be highest. In any case, it is a good idea to check the accuracy of a single test by having more tests before spending any money to fix your home.

Figure 1-2. Major differences in brochure tone.

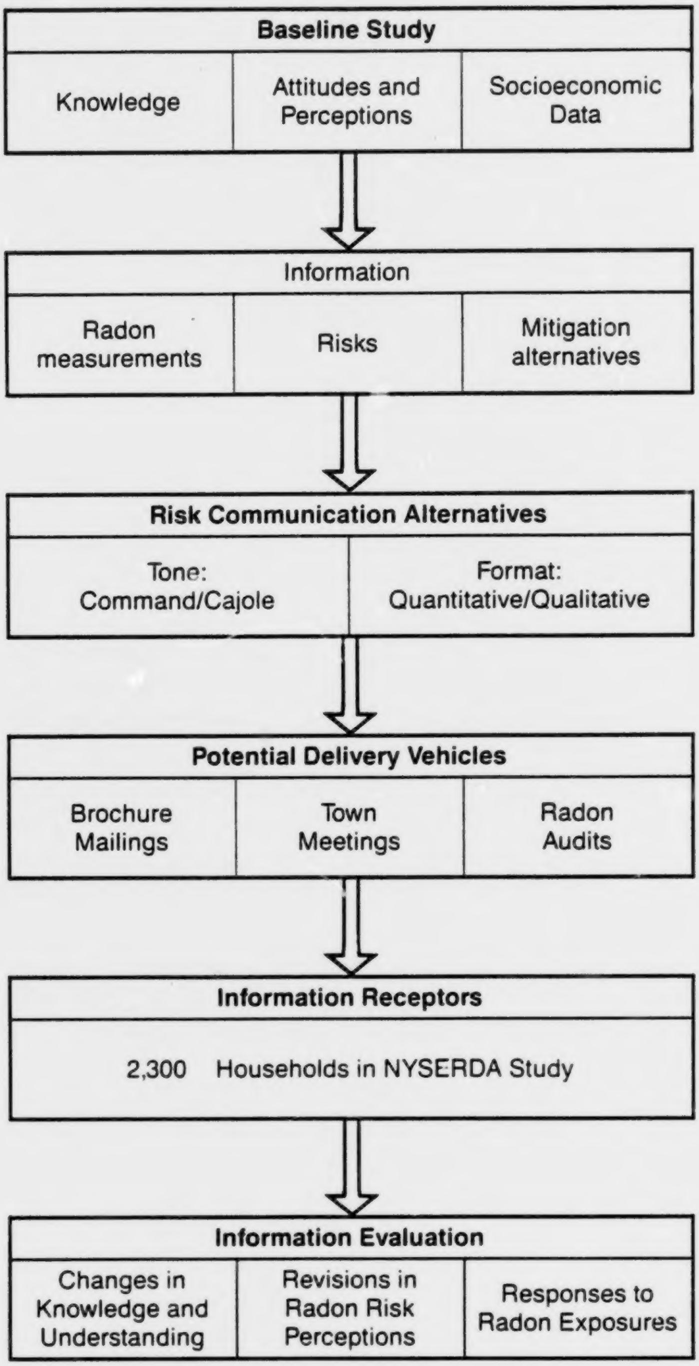

Baseline Study
Knowledge
Attitudes and Perceptions
Socioeconomic Data
Information
Radon measurements
Risks
Mitigation alternatives
Risk Communication Alternatives
Tone: Command/Cajole
Format: Quantitative/Qualitative
Potential Delivery Vehicles
Brochure Mailings
Town Meetings
Radon Audits
Information Receptors
2,300 Households in NYSERDA Study
Information Evaluation
Changes in Knowledge and Understanding
Revisions in Radon Risk Perceptions
Responses to Radon Exposures

Figure 1-3. Overview of radon information study.

Finally, the sixth block summarizes the effectiveness measures used to evaluate the alternative information treatments. Our research design considers four indicators of effectiveness in risk communication:

- Indicator 1: The effectiveness of the brochures in transferring information about radon to individuals
- Indicator 2: The effectiveness of the brochures in helping individuals form perceptions of their radon risks
- Indicator 3: The effectiveness of the brochures in reducing the demand for information
- Indicator 4: The effectiveness of the brochures in motivating high-risk households to reduce their radon levels.

In our Indicator 1 evaluation, we use a "radon quiz" that included a series of questions about radon, its risks, measurement, and mitigation. The evaluation examines how much individuals have learned in each of these areas. Using various models and a wide range of statistical analyses, Indicator 2 explains the factors that affect homeowners' subjective risk perceptions. Indicator 3 evaluates whether alternative communication materials reduce the demand for more radon information.

In this mid-course evaluation, our overall assessment of effectiveness consists of two parts. In Part 1, we evaluate the relationship between homeowners' subjective risk perceptions and technical risk estimates based on EPA's radon risk assessment model. This level attempts to address Russell's concern about whether the right people worry. In Part 2, we address the question, "Which brochure was best?" using each of the three indicators of effectiveness.

At this stage, we cannot completely address the fourth indicator of effectiveness because homeowners would not be expected to take actions on the basis of a single radon measurement. We have, however, used two hypothetical questions to develop a preliminary evaluation of how effectively homeowners perceive the need to mitigate in response to their 2-month readings. Ultimately, our design will track households' actual mitigation activities.

1.4 RESEARCH OBJECTIVES

Seven objectives guide the overall structure of the research. These objectives are to:

- Inform the participating households about two radon measurements: the short-term measure (2-3 months) and an annual measure (12 months)
- Evaluate different formats (e.g., quantitative vs. qualitative) for informing households about their measured radon concentrations, health risks, and possible mitigation actions

- Examine the factors that influence the households' subjective perceptions of risks from radon exposure

- Determine whether participation in the NYSERDA measurement study has affected homeowners' willingness to acquire information about radon or their perceptions of the risks from radon exposure

- Evaluate the effectiveness of risk communication as a policy alternative for managing the risks from radon exposure

- Evaluate the effectiveness of various information treatments on planned and actual mitigation decisions

- Appraise the effectiveness of alternative vehicles (such as town meetings vs. printed materials) to deliver information to homeowners about the risks from radon exposure.

These research objectives are consistent with the needs of information programs in both EPA and NYSERDA. The sequencing of research tasks relative to the ongoing activities in the NYSERDA radon measurement project prevents us from addressing all of these objectives now, but we do address most of them. We view this report as a summary of the findings to date.

1.5 GUIDE TO THE REPORT

This chapter has provided an overview of radon risk communication issues and our approach for examining some of them. Chapter 2 describes the details of the research design that provided the basis for our empirical analysis. Chapter 3 presents our findings on the Level 1 effectiveness: how much homeowners have learned about radon and its risks. Chapter 4 uses several behavioral models to describe how subjective risks respond to the radon risk information alternatives. Chapter 5 examines the demand for more information about radon and appraises the market potential of alternative vehicles to deliver radon information. Chapter 6 summarizes our findings to date on the effectiveness of the risk communication alternatives and highlights future research issues. Appendixes A through D document details about how the research design, sampling, and survey were executed.

1.6 REFERENCES

Adler, R., and D. Pittle, 1984, "Cajolery or Command: Are Education Campaigns and Adequate Substitute for Regulation?" *Yale Journal on Regulation*, Vol. 1, pp. 159-94.

Coyle, Marcia, and Stephen Drachler, 1986, "Officials Tread Lightly in Radon Minefield," *The Morning Call*, October 28, pp. 1-3.

Desvousges, William H., and Mel Kollander, 1986, *Radon Focus Groups: A Summary*, Research Triangle Institute Report to the Assistant Administrator for Policy, Planning, and Evaluation of the U.S. Environmental Protection Agency, January.

Gerusky, Thomas, M., 1987, "Protecting the Homefront," *Environment*, Vol. 29, No. 1, January/February, pp. 12-17, 35-39.

Kasperson, Roger E., and Ingar Palmlund, 1987, "Evaluating Risk Communication," unpublished paper, Center for Technology, Environment and Development, Clark University, February.

Lowry, Tom, 1986, "Trying to See a Colorless Gas," *The Morning Call*, October 28, p. 9.

Pearce, Fred, 1987, "A Deadly Gas Under the Floorboards," *New Scientist*, February 5, pp. 33-35.

Russell, Milton, 1986, Speech to Workshop on Reporting of Health Risk Information by Television, Columbia School of Journalism, New York, New York, April 22.

Sandman, Peter M., 1987, "The Public's Role in Risk Communication," Presentation to the Workshop on the Role of Government in Health Risk Communication and Public Education, Alexandria, Virginia, January 21-23.

Smith, V. Kerry, and William H. Desvousges, 1986, *Measuring Water Quality Benefits*, Boston: Kluwer-Nijhoff.

Smith, V. Kerry, and William H. Desvousges, 1987, "An Empirical Analysis of the Economic Value of Risk Changes," *Journal of Political Economy*, Vol. 95, No. 1, January/February, pp. 89-114.

Viscusi, W. Kip, W. A. Magat, and Joel Huber, 1986, "Informational Regulation of Consumer Health Risks: An Empirical Evaluation of Hazard Warnings," *Rand Journal of Economics*, Vol. 17, Autumn, pp. 351-65.

Wlazelek, Ann, 1986, "Health Risk Not Debated, But Exposure Level is--CDC Says Up to 20,000 Die Each Year Because of Radon," *The Morning Call*, October 28, p. 10.

Yepsen, Roger, 1987, "Radon: The Silent Killer," *New Jersey Monthly*, March, pp. 101-107.

CHAPTER 2

COMMUNICATING RADON RISK EFFECTIVELY: RESEARCH DESIGN AND IMPLEMENTATION

2.1 INTRODUCTION

Radon risk communication involves many complex and often interrelated issues. Some issues stem from the inherent nature of risk such as how to express uncertainty, or how to explain health effects that have long latency periods. Others emanate from the lack of knowledge about what helps people form accurate perceptions of their risks. Other aspects of the effectiveness issue involve the format for expressing the risk--e.g., annual or lifetime risks--or the channel selected to reach the homeowner--e.g., printed media or personal delivery. Such a diversity of issues increases the importance of developing a research design to evaluate the effectiveness of risk communication.

The research design for this study involves an actual risk communication situation--the New York State Energy Research and Development Authority's (NYSERDA's) need to inform the homeowners who participated in its radon measurement study. To take full advantage of this unique opportunity we have collected data that track radon knowledge, risk perceptions, and ultimately the behavior for a large panel of participants. To assess whether homeowners are affected by participating in the measurement study, the design includes a comparison sample of homeowners from the same New York population but who had not participated in the NYSERDA study.

The unique circumstances, however, required that our research design fit within limits that both U.S. Environmental Protection Agency (EPA) and New York State officials found reasonable. This precluded radically different presentations of health effects information that might be desirable in an experimental setting. In addition, both groups had to agree on all recommendations in the brochures. Nevertheless, the design does examine a range of approaches to communicating radon risk information--a fact sheet similar to ones used in various states, four experimental brochures, and EPA's own *Citizen's Guide*.

To show how the research design was developed and implemented, this chapter describes the range of issues considered, the focus groups used to evaluate draft brochures, the establishment of an advisory panel of communication experts to review the research design, and the creation of a statistical design to evaluate effectiveness. Then, it summarizes the survey completions and refusals and gives a profile of the homeowners who are participating in the study.

2.2 DEVELOPING THE RESEARCH DESIGN

For many hazardous or toxic substances, it may be infeasible or prohibitively expensive to regulate the disposal, use, or access to these substances. Increasingly, policymakers are turning to information programs as alternatives to direct regulations. But for these programs to be effective, there is a basic premise that consumers will act rationally. Or, as Viscusi, Magat, and Huber [1986] stated:

> . . . individuals must be able to think systematically about risks and to make sound decisions about uncertainty. (p. 352)

Unfortunately, the definition of a "sound decision" is unclear. Nor is the literature clear on how to communicate risk information or what communication features are likely to affect people's perceived risks and subsequent decisions.

Tests of the expected utility model, the conventional economic model of consumer behavior under uncertainty, have found violations of both the basic assumptions and implied behavioral responses of the individuals involved. Slovic, Fischhoff, and Lichtenstein [1985] explain these findings by noting that most lay people are not trained in how to interpret information about risk. Lay people:

> . . . often are misinformed, rely on suboptimal risk-assessment heuristics, and fail to understand the limits of their own knowledge. (p. 245)

The literature--from either psychology or economics--has not established a consensus on the features of an information program that can be expected to affect how individuals will form their risk perceptions. For example, Viscusi, Magat, and Huber [1986] found that the provision, amount, and format used to convey the hazard warning information for two consumer products, bleach and a drain opener, affected the level of precautions people stated they would undertake. These authors interpret their findings as providing reasonably strong support for the rational model of consumer behavior in the presence of risk.

There is, however, an important qualification to this overall support. Their findings indicate that warnings for the drain opener did not lead to greater precautionary behavior than did those for bleach, even though the drain opener represents a more severe health outcome. They propose two possible explanations for this inconsistent response:

- The bleach labels had greater informational content than those for the drain opener

- There were differences in the amount of learning about the respective hazards.

They suggested that high initial levels of awareness of the risks posed by inappropriate use of drain openers could explain the lower amount of changes in precautionary responses to the drain opener labels.

For our research, the Viscusi, Magat, and Huber [1986] results indicate the need to design the information alternatives so that we can identify how each one influences effectiveness. Moreover, their work implies the need to explicitly model how households use and learn from the information.

Similar conclusions follow from other disciplines. A limited review of other literature (see Payne [1980], Kasperson and Palmlund [1987], Fischhoff, Slovic, and Lichtenstein [1980] as examples) suggests a variety of similar conceptual descriptions of how individuals use information, but these descriptions tend to focus on modeling how individuals use information without a systematic analysis of the content. The information processing approach, for example, emphasizes individuals' limited capacity to deal with and process complex information as an explanation for rules (or heuristics) lay people use to simplify information and thereby permit a decision. One research strategy that follows from this observation is a call for experiments that consider how individuals sequence the processing of information in reaching a decision.

Without a clear consensus on the important features for risk information materials, we drew upon ideas from several sources to structure our research design. First, past research on how individuals assess risk has suggested that the attributes of risk (i.e., voluntariness, dread, extent of knowledge of the risk, latency period, etc.) are important to individuals' risk perceptions (see Slovic, Fischhoff, and Lichtenstein [1985].) Information alternatives that would describe radon's risk in terms of these risk attributes are included as a potential part of the research design. Second, general information on the importance of cognitive factors in the design of product warnings (Kanouse and Hayes-Roth [1980]) suggests that the length and tone of a message can affect how people interpret risk information. Finally, the organization of the information (i.e., hierarchical versus syllogistic) has been suggested as a potential influence to risk communication. Magat, Payne, and Brucato [1986] found that the format used to convey information associated with a home energy audit affects people's responses to the program. Although not directly related to radon risk information, their study provides strong evidence on the effects of information format.

Considering both the risk attribute and the risk presentation issues--length, tone, and format--as the basis for a research design leads to an exceptionally large and unrealistic number of experimental combinations. Consequently, we had to reduce the scope of the potential design for the risk information treatments. We undertook three activities to narrow the range of features considered in the final research design:

- Obtained ideas from a Radon Risk Communication Advisory Panel that EPA formed to provide expert advice on risk communication issues

- Acquired reviews from individuals who are knowledgeable about lay persons' risk assessment and decisionmaking

- Conducted a series of focus groups to evaluate individuals' responses to different information brochures.*

As shown in Table 2-1, the communication experts who served on the Advisory Panel came from a variety of backgrounds. This group played an important role in the decision process. Before meeting with the research team, the panel members reviewed a memo that highlighted the various design issues and a preliminary draft of a radon risk information brochure. During the review session in June 1986, the Advisory Panel considered the full range of issues but emphasized the need to narrow the research focus to a more manageable level. The Panel members generally agreed that an information brochure should be relatively short, be personal, and include color.

Two design features emerged as important: comparing quantitative and qualitative formats for presenting risk information and varying the tone of the brochures. Panel members disagreed about which feature would be more effective. For example, several argued that people have difficulty processing numerical information. They predicted that the brochures with the qualitative formats would be more effective. Others took the opposite position. They also disagreed about which tone would be best. Several felt that the brochures needed a forceful "command" tone, while others argued that the better brochures would have a more persuasive, or "cajoling," tone that encouraged personal evaluation. These features ultimately became the main features of the design as shown in Figures 1-1 and 1-2.

Table 2-1 lists other risk communication experts we consulted. They critiqued the design of the information treatments, the overall research design, as well as the questionnaire used in the followup survey. Equally important, staff from EPA, NYSERDA, and the New York State Department of Health provided comments on the brochures and the research design.

The third element in developing our design consisted of two focus groups conducted in the Clinton, New Jersey, area.† The focus group sessions

---

*Our description implies a somewhat more systematic approach to structure the design than was possible. Partial funding for some of these research activities was obtained for related projects with distinct objectives. Yet there was sufficient complementarity to indirectly contribute to the objectives of this project. For example, focus groups were conducted in Wilkes-Barre with the primary objective of evaluating the EPA *Citizen's Guide to Radon*. The insights derived from this process were used in designing the experimental information brochures.

†EPA's Region II office helped arrange the session with the assistance of the N.J. Radiation Protection Bureau. They recommended Clinton because homeowners in the area had experienced some relatively high readings. Earlier, EPA had conducted four focus groups at two locations in Pennsylvania (Wilkes-Barre and Reading) to help evaluate drafts of EPA's *Citizen's Guide* (see Desvousges and Kollander [1986]).

TABLE 2-1. ACTIVITIES INVOLVING PSYCHOLOGISTS, COMMUNICATION SPECIALISTS, DECISION SCIENTISTS, AND MARKET RESEARCHERS IN VANDERBILT-RTI COOPERATIVE AGREEMENT

Activity	Participants	Area of specialization	Affiliation
Review research design and draft information materials	A. Bisconti*	Communication	Committee for Energy Awareness
	J. Cox	Psychologist	University of North Carolina/RTI
	B. Fischhoff	Psychologist	Decision Research
	J. Huber	Market Researcher	Duke University
	A. Kover*	Market Researcher	Cunningham and Walsh
	H. Kunreuther	Decision Analyst	University of Pennsylvania
	E. Rifkin*	Communication	Rifkin and Associates
	I. Rimer*	Communication	American Cancer Society
	P. Sandman*	Communication	Rutgers University
	E. Shepard	Communication	NYSERDA
	M. Small	Communication	Carnegie Mellon University
	P. Slocum	Communication	New York State Department of Health
	P. Slovic	Psychologist	Decision Research
	T. Wallsten	Psychologist	University of North Carolina
	N. Weinstein*	Psychologist	Rutgers University
Review followup survey design and participate in planning for Phase II	J. Cox	Psychologist	University of North Carolina/RTI
	B. Fischhoff	Psychologist	Decision Research
	J. Huber	Market Researcher	Duke University
	H. Kunreuther	Decision Analyst	University of Pennsylvania
	T. Wallsten	Psychologist	University of North Carolina

*Advisory panel.

involved two small groups of homeowners from the Clinton area. Before the sessions, we mailed each homeowner an introductory letter that explained the purpose of the session, two different brochure drafts, and an evaluation sheet for them to critically rate each brochure. An experienced moderator led each 2-hour session (Desvousges and Cox [1986]). During the sessions, the homeowners discussed their experiences with radon, their overall concerns about radon, and their reactions to the brochures. The participants' evaluation of the draft of the brochures they received was favorable, but they made many useful suggestions for improving them. They suggested that the brochures needed more examples, better titles, and minor organizational changes. Most participants felt that there was enough material on risk, but they were particularly concerned about the lack of available information on mitigation.

All three activities contributed to the final design. They contributed insights into the attributes of the presentation of risk information that are reflected in the brochures, as well as in the overall project activities. The Panel helped target the design, the other experts helped implement the design, and the focus groups provided insights from people very much like the homeowners participating in our study.

2.3 RESEARCH DESIGN

The final design for the radon risk information treatments addresses two main risk communication issues: the use of qualitative-versus-quantitative information to explain risk and the use of command-versus-cajole tone to describe the need for further actions about radon. The quantitative-versus-qualitative feature of the design is straightforward: Does numerical risk information help people to form risk perceptions and make subsequent decisions? Although more difficult to characterize, the command-versus-cajole feature distinguishes between information presented in a directive-versus-evaluative format. The cajole tone encourages individuals to use the information to form an independent judgment about their personal risk, based on their own circumstances and to determine whether further actions are needed. In contrast, the directive approach, designated here as the command tone, emphasizes an expert's (i.e., EPA's) evaluation of what is the appropriate level for action. The role of expert opinion here is analogous to the role physicians or lawyers play in advising an individual on appropriate actions.

We paired each variation of these two design features--command/quantitative, command/qualitative, cajole/qualitative, and cajole/quantitative--to design four distinct information brochures. The distinctions primarily involve the presentation of the risk information. As shown in Figure 1-1, the difference between the quantitative and the qualitative versions appeared in the risk chart and its accompanying explanation. For consistency, both the qualitative and quantitative versions linked radon concentrations to activities with comparable lifetime risks and used colors to distinguish between low increments (green) to lifetime risk versus high increments (red). The quantitative version presented the range of numerical values for the lifetime risk estimates at each radon level. The text of these versions provided an example of how to interpret these ranges. An analogous text was used to describe how to interpret the chart for the qualitative versions. The cajole/quantitative version included estimates of the risk for several exposure times. This information was intended as part of the evaluative tone to assist homeowners in adapting the numerical risk estimates to their own circumstances.

Figure 1-2 in the previous chapter illustrates the differences in the command-versus-cajole tone. For example, by presenting only the EPA Action Guidelines for various radon concentrations, the command variant sought to provide a directive tone while the cajole included three sets of guidelines--the National Council on Radiation Protection, the Canadian government, and the EPA Guidelines--to emphasize the need for judgments about the guidelines. Other subtle differences in tone also were maintained throughout the brochures. For example, the cajole versions highlight how differences in a household's exposure would influence increments to lifetime risk. While more dramatic distinctions may have been desirable from a scientific perspective, they were not feasible within the confines of a behavioral experiment that involved real decisions and actual governmental policy positions. Moreover, the preliminary results indicate that the distinctions used were sufficient to induce measurable differences in households' responses in learning and risk perception.

With one significant exception, the brochures distinguished by the command-cajole attribute provided the same amount of information. The exception involved information on adjustments to the lifetime risk measures. The cajole versions contained additional information that made it easier for the homeowners to adjust their risk, if they decided to do so. For example, the cajole/quantitative version provided a table with numerical ranges of radon risks for 1-year, 10-year, and lifetime exposure periods. The cajole/qualitative version uses three colored columns to communicate the same idea. We did not include this information in the command versions because it was inconsistent with the intent of the command tone's overall communication message.

To the extent possible, we structured the brochures to maintain distinction in the format (quantitative-versus-qualitative) and the tone (command-versus-cajole) without markedly altering the level of difficulty in the material. To evaluate the level of reading difficulty for each brochure variant, Table 2-2 shows the results for several standard readability indexes. Based on word and sentence length, the four indexes ranged from 8th to 11th grade reading levels. The most common readability guide is the Flesch [1948] scale. It is presented in the fourth column of the table. The results indicate that the brochures vary only slightly around the 11th grade level of overall readability. This may overstate their difficulty because of the way the Flesch scale includes technical information on concepts such as risk (see Cherry and Vesterman [1980]). More extensive diagnostic analyses indicated that the brochures have relatively little passive voice and use a minimum of complicated terms.

The last phase of reviews was extensive and occurred over several months. These reviews included New York State officials and EPA staff from several offices. They focused on the health effects information, the information on

TABLE 2-2. READABILITY GRADE LEVELS

Version	Levels			
	Kincaid	Auto	Coleman Liau	Flesch
Command/quantitative	8.9	7.5	9.7	10.9
Cajole/quantitative	9.2	7.7	9.7	11.1
Command/qualitative	8.9	7.5	9.7	10.9
Cajole/qualitative	9.1	7.6	9.8	11.2

the lifetime risks from radon, and the uncertainties associated with each. The resulting concensus led to the final project-designed brochures (labeled as the NYSERDA versions) that are contained in the pocket on the back cover.

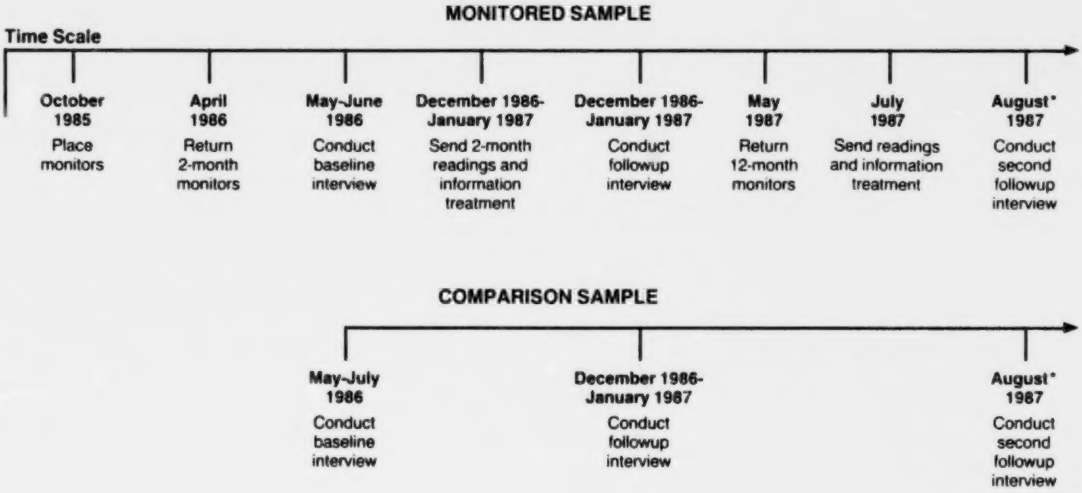
In addition to these brochures, our design includes two other information treatments: the EPA *Citizen's Guide to Radon* (or *Citizen's Guide*) and a fact sheet. The *Citizen's Guide* is EPA's standard radon brochure that covers both the decision to test and how to interpret results. It was not changed in any way for this research. The fact sheet is similar to one NYSERDA had used earlier in communications with households participating in a radon mitigation study. The fact sheet has some general background information and describes risk with the following two paragraphs:

> Recently, the U.S. Environmental Protection Agency has recommended that homeowners within a range of annual average exposure to radon byproducts that is roughly equivalent to a radon concentration range of 4 to 20 picocuries per liter inside their home should act within the next few years to reduce their exposure. For homes with more than 20 picocuries per liter of radon, EPA recommends actions be taken sooner, preferably within several months. The National Council on Radiation Protection and Measurements has recommended that remedial action is advisable if annual average exposure to radon byproducts exceeds a value roughly equivalent to a radon concentration of 8 picocuries per liter.
>
> The measurement collected in your home should not be directly compared to the above guidelines for several reasons: it shows a two-month reading, not an annual concentration; and, since the reading is for a specific location in your home, it does not indicate the exposure level of individuals living in the home.

Thus, the basic research design considered six different information treatments: the four designed to evaluate format and tone effects, EPA's *Citizen's Guide*, and the fact sheet. The overall design isolates features hypothesized to be important in risk communication, along with communication materials now being used. It excludes materials that were known in advance to be inadequate. Even the fact sheet received approval from the relevant State Agencies. There was no evidence to suggest that the fact sheet would perform better or worse than the brochures.

2.4 EXPERIMENTAL DESIGN

The NYSERDA radon measurement study provided a unique opportunity to evaluate the effectiveness of risk communication because it involved a random sample of New York homeowners facing actual decisions about their radon risks and what, if anything, to do about them. Figure 2-1 illustrates the sequence of events associated with our research design activities. Our schedule was partly dictated by the objectives and activities in the measurement study. Because the readings will vary by season, the radon measurement study called for multiple measurements for each home, which varied in the length of the exposure time as well as the location in the house. It included two exposure


MONITORED SAMPLE
Time Scale
October 1985
Place monitors
April 1986
Return 2-month monitors
May-June 1986
Conduct baseline interview
December 1986-January 1987
Send 2-month readings and information treatment
December 1986-January 1987
Conduct followup interview
May 1987
Return 12-month monitors
July 1987
Send readings and information treatment
August* 1987
Conduct second followup interview
COMPARISON SAMPLE
May-July 1986
Conduct baseline interview
December 1986-January 1987
Conduct followup interview
August* 1987
Conduct second followup interview

*Dates contingent upon timing of availability of computer readable file with annual radon readings.

Figure 2-1. Time sequence of activities.

time periods: 2 months and 12 months with the 2-month reading for the winter months and the 12 month readings to yield an annual average.*

Our design includes multiple interviews of each household to construct a time profile of their responses. The first interview constituted a baseline survey, because it was conducted before the households received any information on their radon readings or how to interpret them. As noted earlier, this survey collected information on their knowledge of radon, radon risk perceptions, planned or actual modifications to their homes, and socioeconomic characteristics.

After the 2-month radon monitors were returned and analyzed, we mailed one of the information treatments together with the radon reading for that home. We then conducted a second interview after they had received and read these materials. (We describe the details of these activities in more detail below.) Similar activities and contacts are planned after the annual readings are available. The materials generally advise homeowners not to undertake mitigation on the basis of only one reading. Therefore, we expect that actual mitigation or averting actions would be limited until this later stage. Except for those households with extremely high short-term readings, the prudent response to a radon level indicating some health risk is further measurement to confirm the initial readings.

Households participating in the NYSERDA measurement study will be referred to as the monitored sample. Their participation in the program could influence their responses to information and their willingness to acquire information. Their decision to participate also may reflect a different attitude toward risk than would be held by a nonparticipant. Our research design allows for these possibilities by including a separate sample of households, designated the comparison sample. Using the same sampling criteria that selected the monitored sample, we randomly chose this group of homeowners from people not participating in the measurement study. As of the time of the followup survey, none of the comparison group has tested their homes for radon. We have conducted two interviews with this group in the same timeframes as the interviews with the monitored sample. This allows us to compare their monitored sample's knowledge of radon, risk perceptions, and socioeconomic characteristics with a sample of individuals drawn under the same criteria but free of any potential influence caused by the monitoring program. No information treatments were sent to this group.

Later stages of the research project will address alternative vehicles for delivering radon information. Figure 2-2 shows some options that are being considered. These vehicles are likely to be more effective after the homeowners receive their annual readings and begin to plan their mitigation actions.

---

*The short-term monitors remained in the homes between 2 and 3 months depending on the exact dates they were returned by the households. For convenience, we refer to all of them as the 2-month readings. The actual readings are averaged for the time involved in each case.

Delivery Vehicles	Preliminary Design
Telephone Reinforcement	Applied randomly to one-half of the households above 4 picocuries per liter
Town Meetings	Several meetings. Applied to areas where meetings are feasible.
Radon Diagnostician	Applied in limited areas for random sample above 4 picocuries per liter

Figure 2-2. Experimental design alternative information delivery vehicles.

To evaluate the effectiveness of information describing the risks associated with radon, we randomly assigned one of the six information treatments to each household. Because our research involves households facing real risks, we altered the design to send the fact sheet only to households with measured radon concentrations below 1 picocurie per liter.

The focus group findings suggested that households with higher radon levels wanted more information on mitigation than could be provided in a reasonably short brochure on radon risks. Consequently, households with readings of 1 picocurie per liter or more were sent the EPA mitigation brochure, *Radon Reduction Methods: A Homeowner's Guide*, along with one of the five brochures.

These considerations required that the sample be divided on the basis of the radon reading before the information treatments were randomly assigned. Figure 2-3 defines the design points from the assignment. Households whose dwellings had 2-month radon readings below 1 picocurie were randomly assigned to one of the six design points in the first row of the table, while those with readings 1 picocurie or more were randomly assigned to one of the five cells in the second row. The first number in each box indicates the number of homeowners assigned to a treatment, and the second (shown in parentheses) shows the number of completed interviews for both the baseline and the follow-up surveys.

Appendix A highlights how the radon measurements were included in the overall research design. Appendix B summarizes the statistical tests to ensure that the random assignment was independent of a homeowner's characteristics, especially perceived risks, knowledge, awareness of radon, and radon readings. Because there were relatively small percentages of homeowners with high or very high readings, we did not stratify the design by radon reading.

2.5 MEASURING THE EFFECTIVENESS OF A RISK INFORMATION PROGRAM

Our analysis considers three questions in judging the effectiveness of an information program as a policy instrument:

- Did the target individuals learn anything more about the source or processes responsible for the risk?
- Did they use the information to form new perceptions of their risks?
- Did they change their behavior in response to the information?

The first question simply evaluates whether the program successfully transferred information on the sources of the risks of interest. The second question assumes that the formulation of a reasonably accurate risk perception is a prerequisite to appropriate behavioral action. Using conventional economic criteria, the third requires that effectiveness be associated with tangible actions that involve changes in resource allocation decisions in response to the information.

	Information Treatments					
Below 1 picocurie per liter	NYSERDA Fact sheet 645 (587)	NYSERDA Brochure 1: Command Quantitative 129 (120)	NYSERDA Brochure 2: Cajole Quantitative 129 (120)	NYSERDA Brochure 3: Cajole Qualitative 129 (116)	NYSERDA Brochure 4: Command Qualitative 129 (119)	EPA Citizen's Guide 129 (121)
Above 1 picocurie per liter		NYSERDA Brochure 1: Command Quantitative 201 (189)	NYSERDA Brochure 2: Cajole Quantitative 202 (182)	NYSERDA Brochure 3: Cajole Qualitative 202 (189)	NYSERDA Brochure 4: Command Qualitative 202 (178)	EPA Citizen's Guide 201 (166)

Note: The number of completed interviews is shown in parentheses.

Figure 2-3. Radon risk information—experimental design.

Our effectiveness evaluation implies that the transfer, learning, and updating of risk perceptions should be a central part of the process leading to the final outcome that Viscusi, Magat, and Huber [1986] used as their overall criterion--a sound judgment. Addressing this aspect of effectiveness requires logically structuring the processes through which we can observe and evaluate people's decisions.

We see no reason why an evaluation of effectiveness based on risk perceptions should be viewed as one of the "handy-dandy measuring tools" (offered by consultants) Kasperson warns against. (See Kasperson and Palmlund [1987].) There is growing evidence that these perceptions can be measured in meaningful ways. (See Smith and Johnson [forthcoming] and Desvousges et al. [1987].)

In this research, we are interested in whether the information treatments affect the mitigating actions people undertake. Once the third question is answered, we can evaluate whether the behavioral changes were sound by estimating the implied incremental values for the risk changes. However, there is growing evidence that the attributes of a risk affect how individuals respond to any policy. One important implication of these differences in responses is the expectation that there should be differences in value of the risk changes when risks (or the events at risk) have different characteristics. For example, people are likely to value a given reduction in a voluntary risk differently from the same reduction in an involuntary risk. Thus any implicit values of statistical lives saved that could ultimately come from our effectiveness evaluation will reflect the character of radon risks. To the extent different information treatments led individuals to perceive risks differently (i.e., not only the level of risk but also its attributes), then we would expect differences in mitigation responses across the information treatments.

Evaluating the effectiveness of a risk information program involves subtle considerations. For example, one method to evaluate effectiveness compares personal risk assessments made after receiving the information with the technical risk assessments for the same individuals. Ideally, we would like people to make decisions that reflect the proper amount of precautionary behavior. Unfortunately, the definition of "proper" for policy purposes is not necessarily clearcut. Efficient precautionary behavior can be defined, but this may not be the exclusive criterion used in designing risk policies.

Alternatively, effectiveness could consider whether individuals have access to the best possible technical information. It is in this context that we propose to compare the reported subjective assessments of radon's risks with a technical risk estimate for each individual. But, both measures are estimates. Individuals assess their subjective risks, while "the experts" estimate the technical risks for different types of individuals under specified conditions. Given the limitations of both types of risk assessments, neither is the "true" risk an individual actually faces.

This report considers only the first two forms of effectiveness. As noted earlier, it is too early in the research project to observe mitigation behavior. We need information on these responses before we can evaluate whether specific information programs induce different behavioral responses to radon risks. After the annual radon readings are sent to the households and sufficient time elapses for the homeowners to make their decisions about their risks from radon exposure, we intend to collect and analyze these data.

2.6 SURVEY SAMPLING

The two samples of homeowners from New York State are:

- 2,300 homeowners who are participating in a NYSERDA study that measures radon levels throughout the State (monitored group)
- 252 homeowners in New York State who were not in the NYSERDA monitoring study (comparison group).

Using standard sampling techniques, both samples were drawn randomly from a listing of all New York State telephone numbers. A screening procedure selected eligible homeowners. The target population consists of homeowners who live year-round in single-unit homes and who do not plan to move for 12 months.

The radon measurement study design also developed strata or subgroups to improve the precision of the statistical estimation of radon levels and to identify potential target areas for further study. These strata correspond to different geologic formations in the State of New York:

- Binghamton. This area is of special interest because high levels of radon have been observed in water.
- Undeformed Sediments. Relatively undeformed Paleozoic sediments dominate central and southern New York, from Albany to Buffalo, and south to Binghamton. NYSERDA data indicate that some high radon concentrations have been found in this region.
- Metamorphic Rock. The Adirondack metamorphic/igneous rocks are analogous to those associated with high radon concentrations in water in Maine.
- Deformed Sediments and Rock. East of Albany, and extending down to New York City, there is a belt of complex deformed, orogenic sediments and metamorphic rocks, which is considered a discrete geological region.
- Staten Island. Staten Island is in part underlain by Triassic sediments similar to those associated with unusually high concentrations of radon in the Princeton, New Jersey, area.
- Long Island. Much of Long Island is underlain by glacial sediments, so radon levels should be low.
- New York City. This is not a separate geological region, but the size of the city warrants its individual consideration.

Table 2-3 shows average radon readings for the seven geographical strata. The readings are highest in the Binghamton formation with an arithmetic mean of over 3 picocuries per liter. The radon readings in this stratum ranged from .09 picocuries per liter to 39.8 picocuries per liter with a median of 1.31. Undeformed sediments and deformed sediments strata had the next highest mean radon readings. Readings in New York City, Long Island, and Staten Island are low with mean values of less than 1 picocurie per liter of radon. For a more detailed description of the sampling process and the sample strata, see Appendix C.

2.7 SURVEY DATA COLLECTION

To collect the data for implementing the experimental design, we have conducted four telephone surveys:

- Baseline survey of homeowners in NYSERDA measurement study (monitored group) initiated in May 1986 and completed in June 1986.
- Baseline survey of homeowners not participating in the study (comparison group) initiated in June 1986 and completed in July 1986.
- Followup survey of monitored group in December 1986 and January 1987.
- Followup survey of comparison group in December 1986 and January 1987.

Appendix D contains the survey questionnaires. Tables 2-4 and 2-5 indicate that the data collection efforts have been very effective. For the monitored group, the baseline and followup surveys achieved completion rates of 97 percent and 91 percent. For the comparison group, the initial random digit dialing survey yielded a 50 percent completion rate in reaching the desired (approximately) 250 interviews. Seventy percent of this comparison group completed the followup survey. Experienced professional interviewers, who received extensive training for both sets of surveys, conducted the interviews from Research Triangle Institute's (RTI's) Telephone Survey Center.

2.8 HOMEOWNER PROFILE

The average homeowner in our New York sample is a white female in her mid-forties who has had some college education, has lived in her present home for approximately 15 years, and has an annual before-tax family income of approximately $30,000. Several of the means--the monitored and comparison samples--show differences that are statistically significant. However, the numerical magnitudes of the differences are so small that they are unlikely to affect any subsequent statistical comparisons of the groups. Indeed, the differences are largely explained by the disparity in sample sizes. The same tests for the respondents who completed the followup interviews show only the difference in ages has remained statistically significant. Tests for differences between the baseline and followup samples in Table 2-6 indicated that attrition has not affected the characteristics of our panel.

TABLE 2-3. WEIGHTED SUMMARY STATISTICS (pCi/L) FOR THE NEW YORK STATE RADON STUDY, OVERALL AND BY GEOGRAPHIC STRATA

	Arithmetic mean	Arithmetic standard error	Geometric mean	Geometric standard error[a]	Median	90th percentile	Range
State	1.39	0.05	0.86	1.03	0.86	2.51	0.06 - 39.8
Binghamton	3.34[b]	0.30	1.60[c]	1.08	1.31	8.81	0.09 - 39.8
Undeformed sediments	1.58	0.10	0.95	1.04	0.95	3.21	0.07 - 28.4
Metamorphic sediments	1.09	0.08	0.74	1.05	0.81	1.86	0.06 - 21.6
Deformed sediments and rock	1.82	0.18	1.11	1.07	1.06	3.42	0.08 - 20.9
Staten Island	0.75	0.06	0.63	1.09	0.63	1.22	0.19 - 2.4
Long Island	0.87	0.04	0.69	1.05	0.73	1.75	0.07 - 3.4
New York City	0.81	0.08	0.63	1.13	0.78	1.46	0.08 - 2.4

[a] Exp(s) where s is the standard error of the weighted mean of LN(x).

[b] Arithmetic means significantly different among seven geographic strata.

[c] Geometric means significantly different among seven geograhic strata.

TABLE 2-4. BASELINE AND FOLLOWUP SURVEYS—FREQUENCIES AND RELATIVE FREQUENCIES OF FINAL INTERVIEW RESULTS FOR NYSERDA HOMEOWNERS

Survey result	Baseline survey		Followup survey	
	Frequency	Relative frequency	Frequency	Relative frequency
Completed interview	2,231	0.970	2,087	0.907
Partial data			6	0.003
Unable to contact	38	0.017	30	0.013
Number out of order or other mechanical problems	3	0.001	139	0.060
Dropped out of panel	12	0.005	12	0.005
Final interview refusal	11	0.005	26	0.011
Other	5	0.002		
Total surveys	**2,300**	**1.0000**	**2,300**	**1.0000**

TABLE 2-5. COMPARISON GROUP HOMEOWNERS: FINAL INTERVIEW STATUS BASELINE AND FOLLOWUP

Status surveys	Baseline survey[a]		Followup survey	
	Frequency	Percent	Frequency	Percent
Completed interview	252	49.9	182	72.2
Partial data	1	<1	1	<1
Unable to contact	38	7.6	39	15.4
Final interview refusal	214	42.5	30	11.9
Total	**505**	**100.0[b]**	**252**	**100.0**

[a] To reach these respondents we contacted 882 ineligible households, 1,499 numbers that were out or order, and 794 unable to complete because of reaching answering machines, or other connection irregularities.

[b] Does not add to 100 due to rounding.

TABLE 2-6. SOCIOECONOMIC CHARACTERISTICS OF SURVEY SAMPLES

	Monitored			Comparison		
Variable	**Baseline**	**Followup**	**Both**	**Baseline**	**Followup**	**Both**
Age						
Mean	47.2	47.3	47.3	44.1*	45.1*	45.1
Median	46.0	46.0	46.0	43.0	44.0	44.0
S.D.	14.4	14.2	14.2	15.6	15.4	15.4
Education						
Mean	13.4	13.4	13.4	13.3	13.5	13.5
Median	12.0	12.0	12.0	12.0	12.0	12.0
S.D.	2.4	2.4	2.4	2.3	2.5	2.5
Income						
Mean	31,440	31,587	31,587	32,108	32,854	32,854
Median	30,000	30,000	30,000	30,000	30,000	30,000
S.D.	16,237	16,248	16,248	13,286	15,713	15,173
Years lived at this address						
Mean	15.2	15.2	15.2	14.3	15.0	15.0
Median	12.0	13.0	13.0	10.0	10.0	10.0
S.D.	12.2	12.0	12.0	12.1	12.3	12.3
Race[a]						
Mean	1.05	1.05	1.05	1.09*	1.07	1.07
Median	1.00	1.00	1.00	1.00	1.00	1.00
S.D.	0.31	0.29	0.29	0.36	0.35	0.35
Sex[b]						
Mean	1.58	1.58	1.58	1.66*	1.63	1.63
Median	2.00	2.00	2.00	2.00	2.00	2.00
S.D.	0.49	0.49	0.49	0.48	0.48	0.48

[a] Race is defined as follows:
1=Caucasian
2=Black
3=Hispanic
4=Asian or Pacific Islander
5=Native American Indian

[b] Sex is defined as follows:
1=male
2=female

*Indicates a statistically significant difference in means between the monitored sample and comparison sample.

2.9 IMPLICATIONS

The research design is unique in that it provides an opportunity to monitor and track 2,300 households as they change their perceptions of the risk posed by exposure to radon and ultimately decide whether mitigation actions are needed. The comparison sample of homeowners strengthens the ability of the study to evaluate information programs as distinct from the effects of the monitoring program.

To take advantage of this opportunity, we structured a design that allows differences in the effects of various information treatments to be evaluated by considering learning, risk perceptions, and mitigating behavior. These treatments include specifically designed brochures to evaluate whether people use numerical risk information to form their risk perceptions and whether a directive tone leads to better assessments of personal risks. The design also considers possible interdependencies among these risk-communication issues. Also included in the design are the EPA *Citizen's Guide* and a fact sheet. This design permits specific attributes of a risk communication program to be evaluated in statistical terms.

To study people's behavior under actual circumstances, the research design had to meet certain constraints. All subjects were treated equally and there were no extreme variations in substance or tone. Because provision of information is both a component of the research and a risk information policy action, the design was structured to correspond to the actual policy positions of EPA and the New York State Agencies. While these are important qualifications, the design does include sufficient variation to address several important risk communication issues and to provide an evaluation of the effectiveness of such communications in reducing risks from radon exposure.

2.10 REFERENCES

Cherry, L. L., and W. Vesterman, 1980, "Writing Tools--The Style and Diction Programs," Hill, New Jersey: Bell Laboratories.

Desvousges, William H., and James A. Cox, 1986, "Radon Focus Groups: A Summary," Report to U.S. Environmental Protection Agency, Research Triangle Institute, Research Triangle Park, North Carolina, August.

Desvousges, William H., Richard W. Dunford, James Frey, Howard Kunreuther, Roger Kasperson, and Paul Slovic, 1987, *High-Level Nuclear Waste Repository Risks: Focus Group Findings and Implications for Surveys*, Report prepared for Mountain West and the Nuclear Waste Project Office, State of Nevada, Research Triangle Institute, Research Triangle Park, North Carolina, January.

Desvousges, William H., and Mel Kollander, 1986, *Radon Focus Groups: A Summary*, Research Triangle Institute Report to the Assistant Administrator for Policy, Planning, and Evaluation of the U.S. Environmental Protection Agency, January.

Fischhoff, Baruch, Paul Slovic, Sarah Lichtenstein, 1980, "Knowing What You Want: Measuring Labile Values," in T. Wallsten, ed., *Cognitive Processes in Choice and Decision Behavior*, Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Fischhoff, Baruch, Paul Slovic, Sarah Lichtenstein, S. Read, and B. Combo, 1978, "How Safe is Safe Enough? A Psychometric Study of Attitudes Toward Technological Risks and Benefits," *Policy Sciences*, Vol. 8, pp. 127-52.

Flesch, R., 1948, "A New Readability Yardstick," *Journal of Applied Psychology*, Vol. 32, pp. 231-33.

Kanouse, David E., and Barbara Hayes-Roth, 1980, "Cognitive Considerations in the Design of Product Warnings," in *Banbury Report 6: Product Labeling and Health Risks*, Cold Springs Harbor Laboratory.

Kasperson, Roger E., and Ingar Palmlund, 1987, "Evaluating Risk Communication," unpublished paper, Center for Technology, Environment and Development, Clark University, February.

Magat, W. A., J. W. Payne, and P. F. Brucato, Jr., 1986, "How Important is Information Format? An Experimental Study of Home Energy Audit Programs," *Journal of Policy Analysis and Management*, Vol. 6, Fall, pp. 20-34.

Payne, John W., 1980, "Information Processing Theory: Some Concepts and Methods Applied to Decision Research," *Cognitive Processes in Choice and Decision Behavior*, in T. S. Wallsten, ed., Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Slovic, Paul, Baruch Fischhoff, and Sarah Lichtenstein, 1985, "Regulation of Risk: A Psychological Perspective," in Roger Noll, ed., *Regulatory Policy and the Social Sciences*, Berkeley, California: University of California Press.

Smith, V. Kerry, and F. Reed Johnson, forthcoming, "How Do Risk Perceptions Respond to Information? The Case of Radon," *Review of Economics and Statistics*.

Viscusi, W. Kip, W. A. Magat, and Joel Huber, 1986, "Informational Regulation of Consumer Health Risks: An Empirical Evaluation of Hazard Warnings," *Rand Journal of Economics*, Vol. 17, Autumn, pp. 351-65.

CHAPTER 3

INFORMATION AND LEARNING

3.1 INTRODUCTION

This chapter considers how the New York homeowners used the information materials to learn about radon. In the process we examine the influence of household characteristics and the features of the information materials on that learning. Our analysis is based on two radon quizzes that were administered in the baseline interview and followup interviews. The followup quiz included four questions from the baseline interview that many respondents had trouble answering. The two new questions asked about key concepts that were emphasized in the information materials. The repeat performance analysis allows us to evaluate the effects of the information materials on learning. Results from the comparison sample provide additional perspective on learning that may take place independent of the information materials.

The learning analysis addresses two important aspects of risk communication effectiveness. First, the patterns of responses can tell us what people know, and don't know, about various aspects of radon, and whether the brochures changed that knowledge. Second, the learning patterns can yield insights for understanding the risk perception issues that are considered in the next chapter. Our intuition suggests that systematically linking models of learning and risk perception would contribute to an evaluation of the effectiveness of the brochures in communicating risk. Such linkages, however, remain on the list of future research activities.

3.2 RADON INFORMATION AND AGGREGATE LEARNING

One dimension of the effectiveness of an information program as a policy instrument is whether it successfully transfers new information to the target audience. The homeowners' performance on the radon quizzes provides our primary basis for evaluating the information transfer. Because there was a short time between interviews, and the followup interview had to consider many issues, we could not repeat all the radon quiz questions. To assess learning, we selected questions from the baseline quiz that had a high percentage of incorrect answers but pertained to radon risk and mitigation. We added two new questions that addressed key risk issues, such as the difference between lifetime and annual risks from radon exposure and the potential for symptoms from radon exposure. Table 3-1 provides the text of the questions used in the radon quizzes for the baseline and followup surveys. Those identified with an asterisk correspond to the repeated questions. We administered the quiz to both the monitored and comparison sample. Because of time limitations, our analysis primarily considers the monitored sample.

TABLE 3-1. RADON QUIZ QUESTIONS

Question number[a]	Text of question	Correct answer
A.	**Baseline Survey**	
1	Is radon a a. Colorless, odorless gas b. Or a chemical given off by radar equipment c. Don't know	a
2	Is radon caused by a. Industrial pollution b. Or the natural breakdown of uranium c. Don't know	b
*3	Are high levels of radon likely to cause a. Minor skin problems b. Or lung cancer c. Don't know	b
4	Does the amount of radon in a building depend mainly on the a. Type of machines or appliances in it b. Or the amount of radon in the underlying soil c. Don't know	c
5	Do the risks from radon exposure a. Increase the longer you are exposed b. Or stay the same no matter how long you are exposed c. Don't know	a
*6	When radon is measured in a building, the level will a. Depend on the time of year it is measured b. Not depend on the time of year it is measured c. Don't know	a
*7	Are radon levels usually higher in the a. Basement or lowest floor b. Or the highest floor c. Don't know	a
8	Will people's risk from radon exposure a. Increase if they smoke b. Or stay about the same if they smoke c. Don't know	a
9	Can the level of radon in a home or building be reduced by a. Increasing the amount of air ventilation b. Or by adding attic insulation c. Don't know	a
*10	Are household appliances such as furnaces or clothes dryers likely to a. Increase the amount of radon by lowering inside air pressure b. Or decrease the amount of radon by venting it outside c. Don't know	a
11	Would the effectiveness of ways to reduce radon in homes or buildings a. Be the same for all housing or building types b. Or depend on the features of each home or building c. Don't know	b
12	Will drawing radon away from the home or building before it enters a. Usually involve several thousand dollars and an experienced contractor b. Or depend on the features of each home or building c. Don't know	b

---

[a] The question numbers indicate the position of the questions on each survey. With the baseline survey they were presented first to prevent respondents' answers to other questions affecting their performance on the radon quiz. In the followup survey, the questions were at the end of the interview to attempt to limit the information that would be lost by homeowners refusing to repeat the quiz.

(continued)

TABLE 3-1. RADON QUIZ QUESTIONS (con.)

Question number[a]	Text of question	Correct answer
B.	**Followup Survey**[b]	
31 (3)	Are high levels of radon likely to cause a. Minor skin problems b. Or lung cancer c. Don't know	b
32	High levels of radon exposure a. Will irritate the throat and eyes b. Or will not irritate the throat and eyes c. Don't know	b
33 (6)	When radon is measured indoors, the level a. Will depend on whether the house is closed up b. Or will not depend on whether the house is closed up c. Don't know	a
34 (7)	Are radon levels usually higher a. In the basement or lowest floor b. Or on the highest floor c. Don't know	a
35	Are people's risk from one year of radon exposure a. Much lower than their risk from a lifetime exposure b. Or about the same as their risk from a lifetime exposure c. Don't know	a
36 (10)	Are household appliances such as furnaces or clothes dryers likely to a. Increase the amount of radon by lowering inside air pressure b. Or decrease the amount of radon by venting it outside c. Don't know	a

---

[a] The question numbers indicate the position of the questions on each survey. With the baseline survey they were presented first to prevent respondents' answers to other questions affecting their performance on the radon quiz. In the followup survey, the questions were at the end of the interview to attempt to limit the information that would be lost by homeowners refusing to repeat the quiz.

[b] The number in parentheses are the questions considered to be equivalent from the baseline survey.

Table 3-2 summarizes the test results for the monitored and the comparison samples for three sets of questions grouped according to the type of information requested by the questions--risk, measurement, and mitigation. The NYSERDA monitored sample results are summarized in two ways--for the sample as a whole and also with the sample grouped according to the information treatments they received. The rows in the table correspond to the percentage of correct answers for groups of homeowners included in the design. Percentages are given for both the baseline and followup survey responses. The columns labeled Z are the standard normal statistic for testing whether or not the proportions are equal. (The critical value is 1.645 for a one-tailed test at the 0.05 level of significance.)

The mitigation column reports the percentage of correct answers for only one of the mitigation questions--the one that was repeated in the two surveys. This contrasts with our treatment of the general risk and measurement categories where the percentages relate to all the questions classified in each category for each survey, even when the questions were not the same.

We have focused primarily on the risk and measurement issues because they are more pertinent to this phase of our research. More emphasis will be given to mitigation in the followup of the annual readings when homeowners will have two more readings upon which to base a mitigation decision.

Several interesting findings emerge from the overall test results including:

- Comparing the baseline (B) and followup (F) columns, the NYSERDA sample showed significant increases in learning on all three groups of questions. They answered 91 percent of the measurement questions correctly in the followup survey and 63 percent of the risk questions. Using the repeated mitigation question, the percentage of homeowners answering correctly increased from 14 to 38 percent.

- The homeowners who received the fact sheet did not demonstrate any improvement on the risk questions in the followup survey. They did exhibit improvement with the measurement and mitigation questions. Nonetheless, the performance level in all three categories was below that for homeowners receiving any of the five brochures. For risk questions the fact-sheet group fared about as well as the comparison sample who had received no information.

- The values for the percentage correct responses do differ across information treatments but distinguishing the contributions of each type of brochure to learning is difficult. Generally, all brochures dominate the fact sheet in both the level of knowledge exhibited in the followup survey and the extent of learning indicated by the improvement from the baseline to the followup results.

TABLE 3-2. PERCENT CORRECT BY CLASS OF QUESTION[a]

Information received	General risk			Measurement			Mitigation		
	B[b]	F[c]	Z	B	F	Z	B	F	Z
NYSERDA sample									
Full sample	51.6	62.8	12.82	53.6	91.2	50.50	14.1	38.3	18.59
Fact sheet	52.4	54.5	1.23	57.0	86.0	18.86	12.0	22.1	4.65
COQUANT	52.5	63.1	4.67	57.2	93.6	19.38	15.0	52.6	10.78
COQUAL	52.8	65.7	5.67	56.9	93.0	18.80	18.0	45.2	7.54
CAQUANT	50.2	66.2	7.03	57.9	92.1	17.57	12.3	44.3	9.34
CAQUAL	48.2	65.7	5.67	53.9	94.2	21.46	14.7	46.3	9.04
EPA	52.3	67.2	6.44	55.8	93.5	18.49	14.5	34.3	5.71
Comparison sample	37.5	55.0	6.30	32.5	66.7	11.39	15.9	19.1	0.88

[a] B designates the baseline survey, F designates the followup survey and Z the standard normal test statistic using the normal approximation to the binomial.

[b] The baseline survey had a total of twelve questions. Ten of these were classified into one of the three categories: general risk (3), measurement (3), and mitigation (4).

[c] The followup survey had a total of six questions. When these were classified, three were general risk, two measurement, and one mitigation.

TABLE 3-3. DESCRIPTION OF SOCIOECONOMIC, ATTITUDINAL, AND TECHNICAL VARIABLES

Variable/name	Description
RADON	Radon reading for 2-½ months in picocuries per liter.
AGE	Age of respondent.
EDUCATION	Years of education completed by respondent.
DOCTOR	Attitudinal variable (0,1) from the baseline survey = 1 if a respondent indicated that the statement "you always ask your physician a lot of questions or regularly read articles about health" described himself very or fairly well.
WAIT	Attitudinal variable (0,1) from the baseline survey = 1 if statement: "you usually wait until you have a lot of information before you decide to buy something new like an appliance" described himself very or fairly well.
HEAR	Qualitative variable (0,1) from baseline survey = 1 if respondent had heard or read about radon in last 3 months.
TIME READING	The number of minutes the respondent reported reading the materials explaining how to interpret the radon readings (in the followup survey).
UNDERSTAND	Qualitative variable (0,1) from followup survey = 1 if the individual correctly located his reading on the risk charts provided in the brochures designed by the project or in the EPA *Citizen's Guide*.
COQUANT	Qualitative variable (0,1) = 1 if respondent received the brochure with command and quantitative design features.
COQUAL	Qualitative variable (0,1) = 1 if respondent received the brochure with command and qualitative design features.
CAQUANT	Qualitative variable (0,1) = 1 if respondent received the brochure with cajole and quantitative design features.
CAQUAL	Qualitative variable (0,1) = 1 if respondent received the brochure with cajole and qualitative design features.
EPA	Qualitative variable (0,1) = 1 if respondent received the EPA *Citizen's Guide*.
UNDLIFRISK	Qualitative variable (0,1) = 1 if respondent strongly agreed or agreed that the use of radon risk as a lifetime risk made it easier to understand personal radon risks.
SEX	Qualitative variable, male (=1)

- The comparison group has a lower level of knowledge in all categories in the followup survey than the NYSERDA households. Nonetheless, this comparison group's results do indicate that there was significant learning for the risk and measurement questions. This learning may have resulted from increased awareness caused by our first interviews bringing radon to their attention, or it might simply reflect the media attention given to the subject during the intervening time.

Overall, the performance of homeowners on the quizzes implies that they know the most about measuring radon, but they still have a lot to learn about the risks associated with radon, and especially ways to mitigate those risks. At this stage, the comparison group shows increased learning but the source of learning is unclear.

An earlier analysis of the baseline survey (see Smith et al. [1987]) showed that respondents' characteristics and attitudes did affect the number of correct responses on the radon quiz. Table 3-3 defines the variables used in this analysis as well as in the subsequent analyses in this chapter. The first column in Table 3-4 repeats the estimated model for the total number of correct answers in the baseline survey's radon quiz. The most important explanatory factors were age, sex, education, prior knowledge of radon, and whether a person usually waits until he has a lot of information before making a decision. We found older people performed poorly on the total number of correct answers as well as when subsets of questions for general risk, measurement, and mitigation were analyzed separately. Prior awareness and higher education levels improved performance.

To investigate the effects of the information treatments on performance, we consider the number of correct responses in the radon quiz from the followup survey. A perfect score on the quiz would be six correct answers. Our analysis also considers the number correct for risk and measurement categories. The mitigation category is excluded because it contains only one question.

Table 3-4 also reports the results using Poisson regression to estimate each model. Because the dependent variable involves a count of the correct responses, this regression approach treats the dependent variable as the outcome of a set of independent repeated trials that lead to a discrete random variable, rather than a continuous one. The underlying model assumes that the count of correct responses follows a Poisson process, with the probability of the number of correct responses, y_i, be some integer, a, as determined by Equation (3.1)

$$\text{Prob } (y_i = a) = \exp(-\theta_i) \frac{(\theta_i)^a}{a!} \quad . \tag{3.1}$$

Our regression model assumes that θ_i varies with respondent as:

$$\ln\theta_i = b_o + \sum_{j=1}^{k} b_j X_{ij} \quad . \tag{3.2}$$

TABLE 3-4. TOTAL CORRECT RESPONSES WITH FOLLOWUP RADON QUIZ: POISSON REGRESSION MODELS[a]

Independent variables	Baseline survey	Followup survey						
	Total correct for all questions	Total correct for all questions			Total correct for general risk questions		Total correct for radon measurement questions[b]	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
INTERCEPT	1.4574 (23.101)	.9901 (12.001)	.9970 (12.070)	.7322 (5.192)	.1108 (0.908)	−.2936 (−1.399)	.4108 (3.326)	.2877 (1.397)
RADON	—	.0084 (2.158)	.0097 (2.465)	.0098 (2.500)	.0126 (2.240)	.0143 (2.536)	.0029 (0.474)	.0039 (0.630)
AGE	−.0033 (−5.299)	−.0029 (−3.541)	−.0029 (−3.488)	.0089 (1.681)	−.0045 (−3.639)	.0140 (1.764)	−.0011 (−0.882)	.0048 (0.615)
AGE^2	—	—	—	−.0001 (−2.269)	—	−.0002 (−2.348)	—	−.0001 (−0.760)
EDUCATION	.0198 (5.382)	.0273 (5.779)	.0267 (5.636)	.0258 (5.426)	.0375 (5.383)	.0356 (5.074)	.0109 (1.538)	.0102 (1.432)
DOCTOR	.0302 (1.426)	.0039 (0.148)	.0030 (0.116)	.0100 (0.371)	−.0056 (−0.141)	−.0081 (−0.206)	.0035 (0.087)	.0038 (0.096)
TIME READING	—	.0003 (0.586)	.0004 (0.658)	.0004 (0.759)	.0000 (0.013)	.0001 (0.176)	.0000 (0.020)	.0001 (0.086)
COQUANT	—	.1755 (4.623)	.1335 (3.217)	.1291 (3.104)	.1298 (2.280)	.0670 (1.074)	.0964 (1.707)	.0658 (1.064)
COQUAL	—	.1650 (4.268)	.1202 (2.823)	.1166 (2.733)	.1678 (2.936)	.1022 (1.619)	.0798 (1.382)	.0473 (0.742)
CAQUANT	—	.1598 (4.180)	.1206 (2.917)	.1167 (2.820)	.1699 (3.009)	.1085 (1.772)	.0791 (1.389)	.0495 (0.802)
CAQUAL	—	.1874 (5.004)	.1467 (3.593)	.1468 (2.982)	.2037 (3.692)	.1474 (2.441)	.0941 (1.683)	.0661 (1.084)
EPA	—	.1525 (3.881)	.1258 (3.089)	.1216 (2.982)	.1928 (3.350)	.1499 (2.505)	.0857 (1.469)	.0654 (1.081)
HEAR	.2906 (15.990)	.0623 (2.721)	.6062 (2.647)	.0595 (2.597)	.1063 (3.135)	.1014 (2.990)	.0222 (0.650)	.0204 (0.595)
UNDERSTAND	—	—	.0675 (2.523)	.0682 (2.548)	—	.0938 (2.369)	—	.0477 (1.179)
WAIT	.0801 (3.405)	—	—	.0019 (0.064)	—	.0292 (0.658)	—	—
SEX	0841 (4.626)	—	—	.0307 (1.307)	.0252 (0.729)	.0320 (0.923)	.0246 (0.704)	.0278 (0.794)
Log (L)	27,425	10,010	10,013	10,017	158.1	164.13	−276.9	−275.87
χ^2	2,246.3	642.52	638.3	632.71	746.26	739.01	184.24	183.25
n	2,016	1,936	1,936	1,936	1,936	1,936	1,936	1,936

[a] The numbers in parentheses are the ratios of the coefficient to their estimated asymptotic standard errors.

[b] The baseline survey contained only two questions in the measurement category. Convergence was satisfied but the summary statistics indicate large gradients. This model will require further analysis before we can gauge whether there are too few questions for the Poisson count framework, or whether more extensive search of the likelihood surface is required. The results should be regarded as preliminary.

The likelihood function can be derived from Equation (3.1). To estimate the model we follow Maddala's [1983] iterative process.

The Poisson regression approach has both advantages and disadvantages. Its primary advantage is that it accounts for the discrete nature of the dependent variable. Its main disadvantage stems from the assumption that the mean and variance of the population of correct answers (for each type of respondent) are equal. In our model the mean, θ_i, may vary with the X_j's, which allows for heteroscedasticity across individuals, but the equality of means and variances for each type of respondent is not often upheld. This implies that the estimated standard errors for the model's parameters can be lower than is warranted. In analyzing the number of patent applications, Hausman, Hall, and Griliches [1984] found that the estimated standard errors for parameters in a linear model estimated with maximum-likelihood (ML) methods under the assumption of a Poisson process were one-third the ordinary least-squares (OLS) estimates. These findings imply that a ML estimator for the variance covariance matrix can be sensitive to violations in the assumption of equal means and variances.

Our model considers several determinants of the average number of correct answers including a homeowner's radon readings, socioeconomic characteristics, prior awareness of radon, attitudinal variables, and the type of information treatment received. The information treatments are included as qualitative variables (i.e., 0, 1 variables) with the fact sheet the omitted category implying that each coefficient for the remaining information variables indicates its differential effect on the mean count of correct answers.

In discussing our basic estimates, we concentrate on the results for Model 3, which is based on the total number of correct answers in the followup survey. These estimates indicate several significant determinants of this measure of knowledge. The information brochures consistently increased homeowners' knowledge, even after accounting for the effects of a radon reading and socioeconomic characteristics. All the NYSERDA versions and the EPA *Citizen's Guide* lead to higher levels of knowledge than the fact sheet. While the estimated parameters are rather close, there does seem to be a consistent advantage (in the relative size of its differential over the fact sheet) to the cajole/qualitative version of the brochures. The mean radon reading is also positively related to the count of correct answers. Individuals with higher radon readings seem to be more inclined to pay attention to the information provided and to retain it, at least within the limits that could be examined in this first followup contact.

Three aspects of the respondents' socioeconomic characteristics are especially interesting. First, increases in age decrease the mean count of correct responses. This result supports the earlier findings for the baseline survey of the monitored sample (see Model 1 in the first column of Table 3-4). This is the first indication of a consistent pattern of difficulties in designing information programs to communicate risk information to older people. To provide insight into the effects of age, we considered one modification to the basic models--the inclusion of quadratic terms in age for the total correct response model and those for the two categories of information shown in models labeled (4), (6), and (8). This is only one approach to examine the effects of age. Other approaches include: examining subsets of the overall sample, classified by age; analyzing residuals with regression diagnostics; and performing a parametric analysis of the treatment of age in these models. To fully understand the effects of age all should be considered, but this was not possible for this mid-course evaluation.

The models for the total number correct and the count of correct answers for the risk questions support the inclusion of a quadratic term. Based on these models, increases in age initially lead to improved scores but later lead to declines in the number of correct answers. The point of inflection (i.e., where the change in mean correct answers with respect to age is zero) occurs at about 45 years of age with the total number of correct model and at 35 with the model for the number of correct risk-related questions. This analysis suggests that there may well be a payoff to further analysis of the sources of older homeowners' differential learning.

The second socioeconomic variable of interest is education. The results show that increases in education consistently increase the mean correct responses, again consistent with earlier evidence. Individuals who had read or heard about radon before the baseline survey also performed better. The statistically significant influence of education suggests that differences in radon knowledge can be explained by factors that affect knowledge in general. The significance of the awareness variable (HEAR) for all questions implies that the various contributors to awareness about radon--radio, television, and newspaper articles--do affect knowledge. Such influences are essential in a radon information program, particularly one that would use these media to disseminate radon information.

Our results show that the reported time spent reading the materials was not a significant determinant of radon knowledge. This variable could indicate difficulties in processing the information materials. Like age, however, the relationship may not be linear. More evaluation of this relationship seems useful.

A more specific measure of successful use of the brochures, UNDERSTAND, was a positive and significant determinant of the total count of correct responses. As we discuss in more detail in the next chapter, this variable is based on the respondents' recall of where their radon reading was located on the risk charts. We view it as a crude proxy for differences in the respondents' understanding of the risk materials. For the learning models, the coding of this variable also affects the size of the differential of the brochures over the fact sheet because homeowners receiving the fact sheet were grouped with the incorrect recall group. This probably explains the decline in the magnitude of these estimated coefficients for the qualitative variables for the information brochures when UNDERSTAND is included in the model. Strictly speaking, this is inappropriate because homeowners receiving the fact sheet could not respond to the question, and we would expect some of the effects of the information treatment to be reflected in this variable.

The results for the models estimated using the types of information associated with the questions--general risk and measurement--are presented in Models (5) and (6), and (7) and (8), respectively, of Table 3-4. With the general risk questions, the results are comparable to those for the total correct--a strong endorsement for the brochures over the fact sheet, a clear positive effect of the radon reading, education, and prior information, and a negative effect of age after a threshold point. The measurement questions are not very illustrative and the model did not perform as well. There were only two measurement questions which may account for the poorer performance.

In summary, these results show that, compared to the fact sheet, the brochures enhance knowledge about radon and may encourage learning. Higher radon readings seem to provide separate learning incentives. Not surprisingly, more educated and more aware homeowners also showed more knowledge about radon. The consistently poor performance of older people, even after controlling for education and awareness differences, indicates the prospect of problems in using information programs for communicating risks to this group.

3.3 REPEATED QUESTIONS AND LEARNING

This section analyzes the results of the questions that were repeated in the two surveys. Until now, our analysis has assumed that the questions in the baseline and followup surveys have similar levels of difficulty. To satisfy this assumption would have required identical quizzes in both surveys. Whether such control is desirable is an open question. Few insights into people's learning about radon risk can be gained from questions that nearly everyone answered correctly in the baseline survey. Since the two interviews were only a few months apart, we could have increased the potential for refusals by asking the same questions.

Recognizing these tradeoffs, we repeated (almost verbatim) four of the twelve questions from the baseline survey and added two new questions. We chose questions that covered important topics and had a high proportion of incorrect answers in the baseline interview. Putting the quiz at the end of the interview for the monitored sample also helped reduce potential repetition problems.

The repeated questions provide an opportunity to analyze respondents' performance with a constant standard over the two surveys. With such questions, four outcomes are possible:

- Response to the baseline could be correct and to the followup be wrong (unlearn)
- Both responses could be wrong (wrong on both)
- Both responses could be correct (right on both)
- The response to the baseline could be wrong and to the followup be correct (learn).

We consider the fourth response a reflection of learning and the first an indication of confusion or simple guessing. The third is not informative since there is no change in performance. The second is an important benchmark because it indicates a failure to transfer information.

There is no natural aggregation of these outcomes because each reflects a unique state of how respondents processed the information. Therefore, our analysis views each possibility as a distinct event. Figure 3-1 describes responses to a general-risk question that focuses on the primary health effect of radon--skin problems versus lung cancer. The results indicate considerable learning or retention of prior knowledge. About 40 percent of the households receiving one of the brochures improved their performance. Over 30 percent of the remainder in these groups maintained correct answers. The fact sheet does not, as we expected from the findings reported in the previous section, lead to as much learning as the other information treatments. It also has a higher rate of apparent confusion, or guessing, with a larger fraction of households going from correct to incorrect responses.

Figure 3-2 shows the same classification for a question concerning whether radon levels depend on whether the home is closed up. We classified this as a measurement question, although it could also affect mitigation. Here we find a greater proportion of the respondents seemed to learn--over 50 percent in all cases. The fact sheet, EPA *Citizen's Guide*, and command/qualitative brochure seem to lead to approximately comparable learning, while the remaining three have somewhat higher percentages. Overall, the information treatments seem quite comparable for this question.

Figure 3-3 continues the focus on measurement by asking for comparisons of the radon concentrations at different floors within the home. Here we find a good level of general knowledge, with almost 60 percent answering the question correctly in both surveys. Learning is also significant with approximately 20 percent of each group going from incorrect to correct responses. The performance of the fact sheet was comparable with the brochures, probably because this issue--concentrations of radon by the level above ground in the house--was explicitly mentioned in the fact sheet.

Figure 3-4 reports the results for the mitigation question, showing that respondents had difficulty with this question. Seventy percent of those receiving the fact sheet reported an incorrect answer in both interviews, while the percentage was less with the other information treatments. The EPA *Citizen's Guide* had a fairly poor record as well, with over 60 percent wrong on both. The project-designed brochures led to the most learning, with percentages twice as large as the fact sheet, and about 10 percent higher than the *Citizen's Guide*. This issue was discussed in the NYSERDA brochures but received less attention in the *Citizen's Guide*. It was not discussed in the fact sheet. Overall, the highest percentage of learning in this case remained fairly low at about 40 percent with the command/quantitative version of the brochure.

As with the count of correct answers, these aggregate proportions of correct answers assume all individuals had identical responses to the mate-

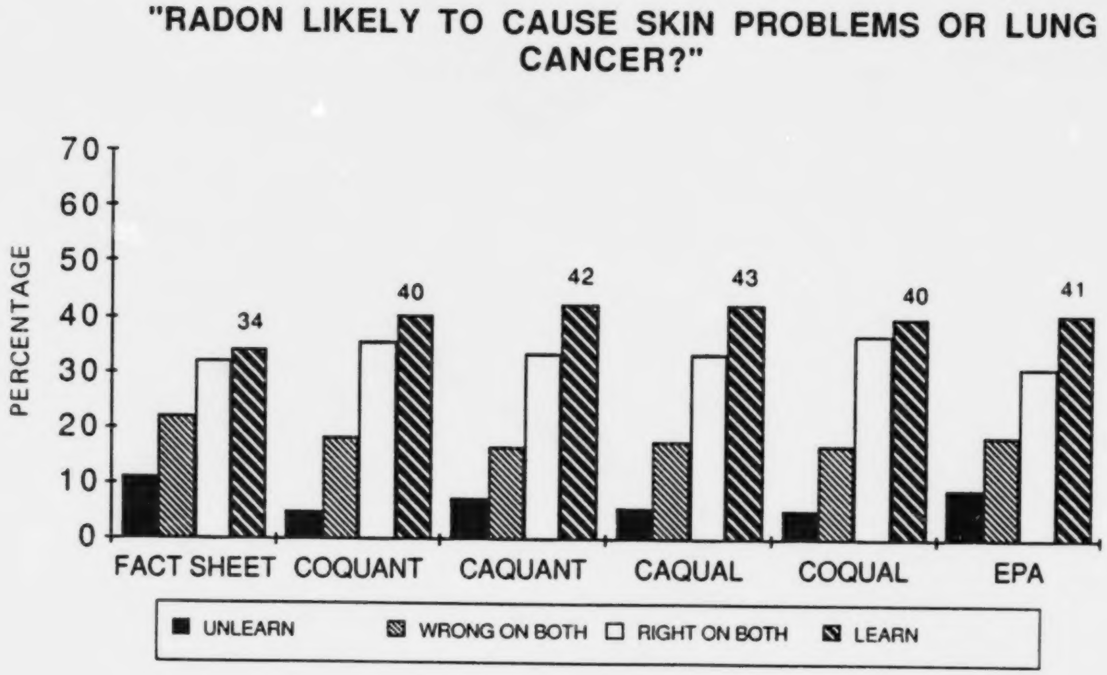


Figure 3-1. Skin problems versus lung cancer.

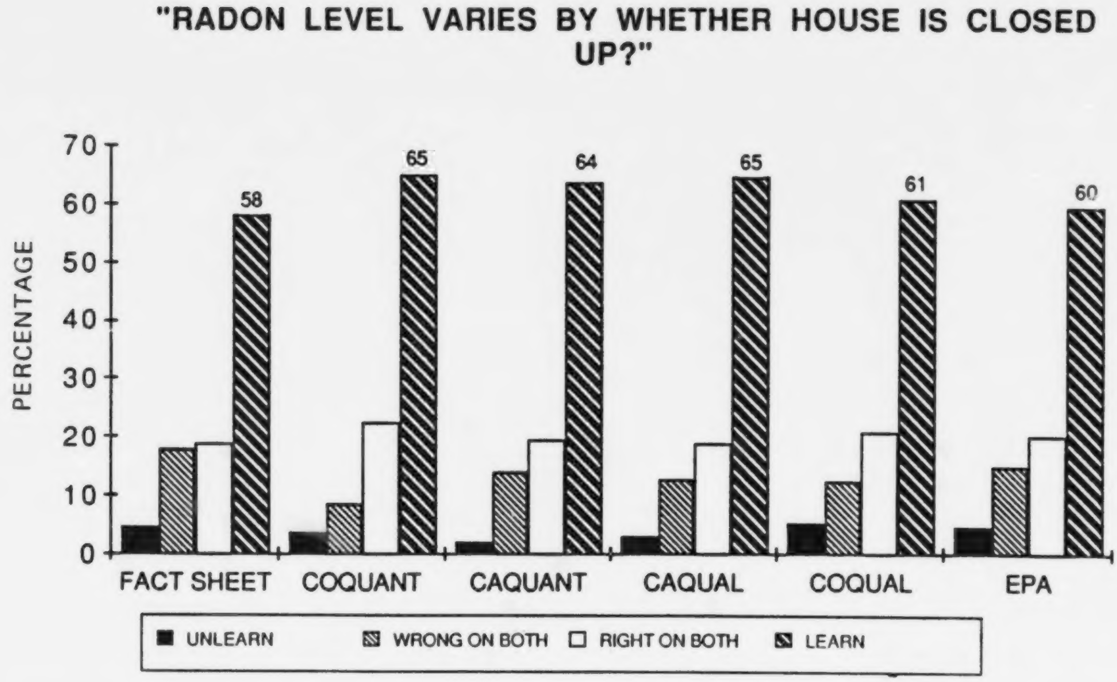


Figure 3-2. Differences in radon measurements.

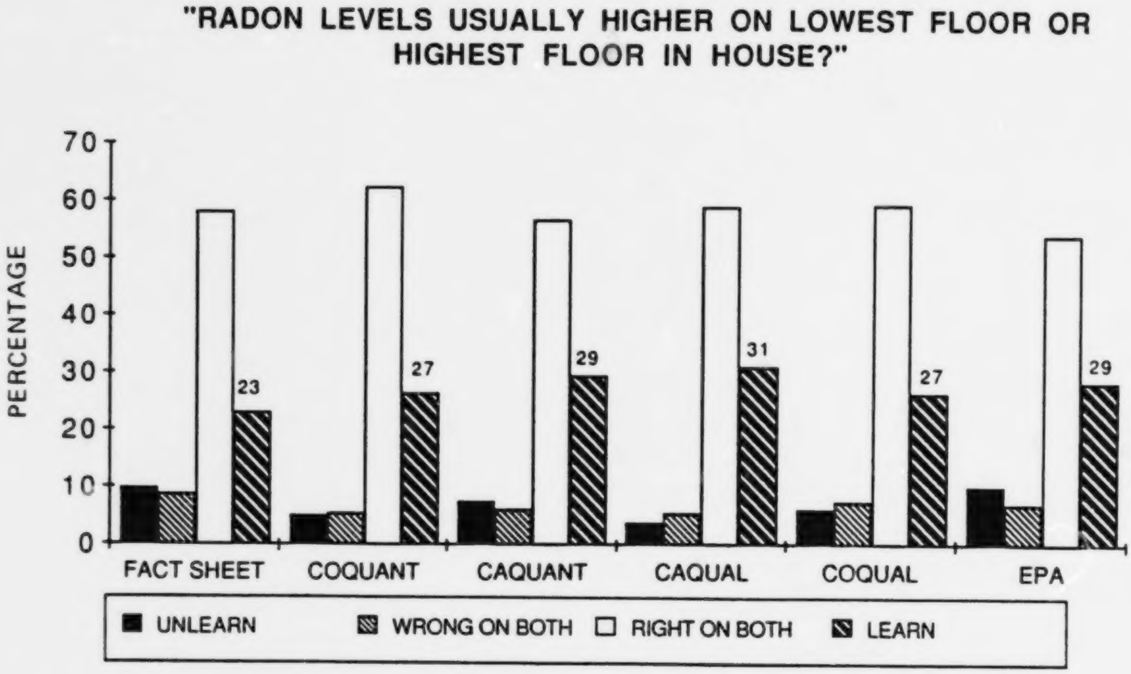

"RADON LEVELS USUALLY HIGHER ON LOWEST FLOOR OR HIGHEST FLOOR IN HOUSE?"

Figure 3-3. Comparisons of radon concentration.

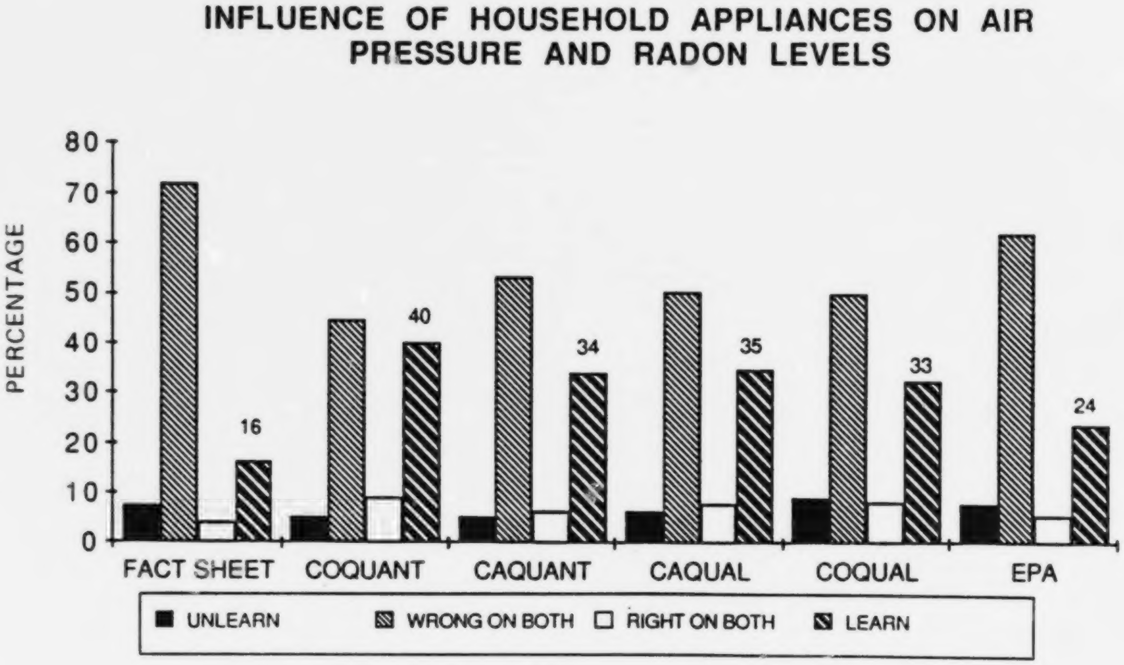

INFLUENCE OF HOUSEHOLD APPLIANCES ON AIR PRESSURE AND RADON LEVELS

Figure 3-4. Mitigation question results.

rials, regardless of their radon readings, age, education, or other characteristics. Table 3-5 reports a multivariate analysis of the repeated questions which accounts for these influences. We examine the four possible outcomes across the two surveys and model the determinants of the probabilities that individuals will attain one of these four outcomes with each question. Our analysis uses a multinomial logit model with the probability of one of the four states given as:

$$\text{Prob (state} = i) = \frac{\exp\left(\sum_j a_{ij} X_j\right)}{\sum_{k=1}^{4} \exp\left(\sum_j a_{kj} X_j\right)} \tag{3.3}$$

where

state = one of four outcomes: correct on both; incorrect on both; incorrect on baseline and correct on followup (i.e., learning); and correct on baseline and incorrect on followup (unlearn)

X_j = j^{th} determinant of probability, constant across states, varying across respondents.

To identify the parameters of the model, a normalization must be imposed. We have measured the parameters relative to the base case of both incorrect. Thus, the three states described in the models in Table 3-5 are unlearn, learn, and both correct.

The models reported in Table 3-5 all adopt a common specification that uses qualitative variables for the information treatments. A significant positive coefficient for one of these qualitative variables indicates that the associated information treatment increases the probability that a respondent would be classified in the learning state relative to the normalizing case of incorrect responses in both surveys. These qualitative variables distinguish between the omitted category--the fact sheet--and one of the brochures.

The results of this multivariate analysis are consistent with earlier findings and with the general conclusion that the brochures induce learning. However, the effects appear to differ across questions. The command/qualitative version is the significant determinant of learning about the health effects of radon, while all versions are significant determinants (over the fact sheet) of learning about the radon levels with the house closed and the mitigation question. Three brochures--COQUANT, CAQUAL, and EPA's *Citizen's Guide*--were significant for the question on how radon concentrations vary at different levels in the house. A comparison of the relative sizes of the significant coefficients for the probability of learning indicates that different brochures would lead to the highest increments to the probability with each question. The command/quantitative version has the largest effect for the measurement/house closed and the mitigation questions, and it would rank second largest for the measurement/radon reading by location question.

TABLE 3-5. MULTINOMIAL LOGIT MODELS FOR QUESTIONS REPEATED ON BASELINE AND FOLLOWUP SURVEYS[a]

Independent variables	Risk—health effects (Q31)			Measurement—house closed (Q33)			Measurement—reading by location (Q34)			Mitigation—effect of appliances (Q36)		
	Unlearn	Learn	Both correct	Unlearn	Learn	Both correct	Unlearn	Learn	Both correct	Unlearn	Learn	Both correct
INTERCEPT	-.7576 (-0.918)	.0002 (0.000)	-.7081 (-1.324)	1.6055 (1.134)	.2792 (0.453)	-.4687 (-0.689)	-.7245 (-0.552)	.8441 (-0.829)	.0996 (0.100)	-2.0065 (-3.011)	-2.2675 (-5.766)	-4.4200 (-6.454)
RADON	.0474 (0.715)	.0813 (1.856)	.0925 (2.104)	.1417 (1.639)	.1143 (1.821)	.1009 (1.561)	.2260 (1.331)	.1925 (1.191)	.2443 (1.517)	-.0115 (-0.270)	.0206 (1.057)	.0348 (1.227)
COQUANT	-.4544 (-1.182)	.3731 (1.559)	.2982 (1.228)	.6031 (0.923)	1.1034 (3.480)	1.0610 (3.096)	.5630 (0.832)	1.3547 (2.386)	1.3172 (2.363)	.2420 (0.710)	1.3013 (7.282)	1.3070 (4.239)
COQUAL	-.4928 (-1.159)	.5193 (2.026)	.5294 (2.049)	1.0273 (1.899)	.7684 (2.604)	.7013 (2.164)	-.5435 (-0.812)	.7949 (1.689)	.7005 (1.528)	.7000 (2.374)	.9899 (5.373)	1.0884 (3.435)
CAQUANT	-.5415 (-1.410)	.3211 (1.365)	.1161 (0.481)	-.4318 (-0.531)	.7573 (2.719)	.6075 (1.960)	-.1014 (-0.646)	.6832 (1.585)	.4331 (1.031)	.2236 (0.698)	.9187 (5.133)	.6547 (1.950)
CAQUAL	-.7535 (-1.898)	.3025 (1.315)	.1108 (0.470)	.1016 (0.160)	.6248 (2.332)	.4524 (1.504)	-.5316 (-0.646)	1.5386 (2.723)	1.2862 (2.309)	.4072 (1.335)	.9759 (5.487)	.9655 (3.065)
EPA	-.1585 (-0.414)	.5084 (2.016)	.3236 (1.254)	.4299 (0.665)	.8064 (2.722)	.7751 (2.391)	.4014 (0.621)	1.2403 (2.356)	1.0049 (1.944)	.3724 (1.221)	.4888 (2.572)	.4866 (1.417)
TIME READING	.0022 (0.297)	.0067 (1.609)	.0042 (0.978)	-.0389 (-2.431)	-.0063 (-1.480)	.0020 (0.448)	-.0052 (-0.537)	.0004 (0.052)	-.0056 (-0.826)	-.0033 (-0.614)	.0051 (1.973)	.0062 (1.535)
DOCTOR	-.0413 (-0.160)	.0367 (0.224)	.2357 (1.386)	-.1181 (-0.285)	.0507 (0.254)	-.0694 (-0.317)	-.3819 (-0.918)	-.2568 (-0.774)	-.0859 (-0.265)	-.1633 (-0.790)	.1614 (1.281)	.2849 (1.261)
AGE	.0058 (0.722)	-.0123 (-2.393)	-.0109 (-2.084)	-.0057 (-0.437)	-.0114 (-1.918)	-.0153 (-2.308)	.0203 (1.598)	.0001 (0.010)	-.0041 (-0.424)	-.0177 (-2.579)	-.0107 (-2.784)	-.0136 (-2.024)
EDUCATION	-.0084 (-0.173)	.0860 (2.801)	.1263 (4.070)	-.2040 (-2.310)	.1194 (3.253)	.0954 (2.363)	.0087 (0.110)	.0605 (0.978)	.1845 (3.066)	.0486 (1.254)	.0907 (4.084)	.1396 (3.713)
SEX	-.1312 (-0.563)	.0353 (0.240)	-.1190 (-0.790)	.2120 (0.553)	.4158 (2.307)	.7169 (3.633)	-.2151 (-0.918)	-.2650 (-.928)	.0976 (0.352)	.1189 (0.624)	.055 (0.524)	.0940 (0.497)
Log (L)	-2,223.4			-1,679.6			-1,622.7			-1,989.4		
n	1,936			1,936			1,936			1,936		

---

[a] The numbers in parentheses are the ratios of the coefficient to their estimated asymptotic standard errors.

The EPA *Citizen's Guide* variable is significant for all questions, but never has the largest numerical effect (relative to the fact sheet).

Why the NYSERDA brochures performed differently on these learning issues is unclear. These brochures were designed to provide exactly the same information on the issues covered in the repeated questions. The command versions, which perform somewhat better, were slightly shorter because they did not include as much information on annual versus lifetime risks. Whether this slight difference explains the performance difference deserves more examination. The learning differential of all the brochures relative to the fact sheet is clear, however. The fact sheet, even though it explicitly covered three of the four topics, was not as effective in helping people learn.

Education has a significant positive influence on learning, while age had a negative and significant influence for three of the four questions. To investigate the effects of age on this measure of information transfer, we included quadratic terms in age. Generally, our results indicate that age has a linear effect on learning in Questions 33 and 36 and has a quadratic effect on learning in Questions 31 and 34, the risk/health effects and the measurement/radon reading by location questions. As shown in the revised models in Table 3-6, increases in age lead to higher learning up to a point and then to decreases in learning. Solving for the inflection points in each case leads to thresholds (i.e., where the effect of age on the probability of learning is zero) of 40 years of age for health effects and 49 for measurement/radon readings by location. In the risk health effects question (Q31) in Table 3-6, the command/qualitative and EPA brochures continue to exhibit a significant positive influence on learning over the fact sheet. As in the Table 3-5 results, the command/quantitative, cajole/qualitative and EPA brochures exhibit significant positive effects on learning over the role of the fact sheet.

These results provide strong support for information programs with carefully designed brochures to transfer risk information. Based on these fairly crude proxy measures (i.e., the count of correct answers and the performance of repeat questions) for learning, it appears that no single format--e.g., command/quantitative versus cajole/qualitative or the *Citizen's Guide*--would be best for all situations. With some types of information, the ability to transfer an understanding was enhanced by adopting a specific format that might be less effective with another type of information.

3.4 CONCLUSIONS

This chapter has analyzed homeowners' learning about radon in two principal ways: how many questions did they answer correctly in the "radon quiz" overall, and how did they perform on questions in three specific categories--measurement, risks, and mitigation. In each case, we have examined the effects of the various information materials, as well as the effects of their socioeconomic characteristics, attitudes, and radon reading on the numbers of correct responses. Our analysis also considered the determinants of performance patterns with four repeated questions. We found that:

TABLE 3-6. REVISED MULTINOMIAL LOGIT MODELS—ALTERNATIVE TREATMENT OF AGE VARIABLE

Independent variables	Risk health effects (Q31)			Measurement—reading by location (Q34)		
	Unlearn	Learn	Both correct	Unlearn	Learn	Both correct
INTERCEPT	−.0467	−1.4841	−2.8011	−.0115	−1.4033	−2.2575
	(−0.036)	(−1.751)	(−3.176)	(−0.006)	(−0.932)	(−1.550)
RADON	.0475	.0815	.0933	.2227	.1872	.2391
	(0.721)	(1.872)	(2.132)	(1.323)	(1.169)	(1.498)
COQUANT	−.4490	.3645	.2848	.5702	1.3533	1.3138
	(−1.166)	(1.520)	(1.169)	(0.841)	(2.376)	(2.349)
COQUAL	−.4845	.5114	.5184	−.5387	.7827	.6875
	(−1.140)	(1.994)	(2.003)	(−0.806)	(1.662)	(1.498)
CAQUANT	−.5275	.2996	.0860	−.0879	.6493	.3972
	(−1.374)	(1.272)	(0.356)	(−0.157)	(1.505)	(0.944)
CAQUAL	−.7556	.3100	.1225	.5362	1.5520	1.3000
	(−1.903)	(1.346)	(0.518)	(−0.651)	(2.743)	(2.332)
EPA	−.1497	.4944	.3038	.4044	1.2173	.9806
	(−0.391)	(1.959)	(1.175)	(0.625)	(2.308)	(1.893)
TIME READING	.0016	.0072	.0048	−.0057	.0011	−.0048
	(0.236)	(1.718)	(1.120)	(−0.581)	(0.159)	(−0.703)
DOCTOR	−.0473	.0440	.2437	−.3854	−.2376	−.0666
	(−0.183)	(0.268)	(1.430)	(−0.926)	(−0.716)	(−0.205)
AGE	−.0233	.0534	.0826	−.0029	.1020	.1029
	(−0.523)	(1.757)	(2.594)	(−0.044)	(1.942)	(2.036)
AGE^2	.0003	−.0007	−.0010	.0002	−.0010	−.0011
	(0.643)	(−2.179)	(−2.976)	(0.283)	(−1.976)	(−2.157)
EDUCATION	−.0096	.0848	.1249	.0045	.0571	.1809
	(−0.198)	(2.762)	(3.996)	(0.057)	(0.930)	(3.028)
SEX	−.1412	.0499	−.1001	−.2091	−.2200	−.1433
	(−0.605)	(0.338)	(−0.662)	(−0.567)	(−0.767)	(0.514)
Log (L)		−2,216.5			−1,617.6	
n		1,936			1,936	

- Information treatments had different effects on learning both by subject area and in the repeated questions. All the brochures are superior to the fact sheet. There also appear to be differences in the performance of some types of brochures but no single brochure was superior in transferring information in all categories.

- In the followup survey, homeowners in the monitored study answered over 90 percent of the measurement questions correctly and about 60 percent of the risk questions. Only 40 percent answered the mitigation question correctly, but this was an especially difficult question.

- Homeowners with higher radon levels showed higher overall knowledge than homeowners with lower radon levels. However, the learning results were mixed with only two of the four repeated questions showing higher radon levels leading to increased learning.

- Older people had more difficulty with the radon quiz. They performed worse on the quiz and did not learn as much between the surveys as their younger counterparts. The relationship between age and learning appears to be nonlinear, with learning increasing up to a threshold, ranging from about 40 to 50 years of age, and decreasing thereafter.

- Education, prior awareness, and demonstrated ability to use the information generally increase learning, as measured by the performance on the radon quiz and by the changes in performance with specific questions.

Our results on learning imply that the homeowners in the monitored sample did show substantial learning. The comparison sample also showed improvement on the radon quiz, suggesting that more analysis of this group is warranted. This improvement could reflect increased knowledge because of the increased media attention given to radon. If so, this would be another indication that information about radon can be transmitted to individuals. What is necessary to better understand the learning relationships is a more thorough examination of the factors that have affected learning for both samples of homeowners. With this understanding, it may be possible to link learning to the formation of risk perceptions and, ultimately, to mitigation decisions. Such insights may even be transferable to the analysis of factors that influence the decision to test for radon.

3.5 REFERENCES

Hausman, Jerry, Bronwyn H. Hall, and Zvi Griliches, 1984, "Econometric Modes for Count Data With an Application to the Patents--R&D Relationship," *Econometrica*, Vol. 52, July, pp. 909-38.

Maddala, G. S., 1983, *Limited-Dependent and Qualitative Variables in Econometrics*, New York: Cambridge University Press.

Smith, V. Kerry, William H. Desvousges, Ann Fisher, and F. Reed Johnson, 1987, *Radon Risk Perceptions and Risk Communications: Preliminary Results*, Interim Report, Vanderbilt University, Nashville, Tennessee, and Research Triangle Institute, Research Triangle Park, North Carolina, March.

CHAPTER 4

THE EFFECTS OF INFORMATION ON RADON RISK PERCEPTIONS

4.1 INTRODUCTION

This chapter evaluates how homeowners used the risk information materials to form their risk perceptions. Using the experimental design described in Chapter 2, we examine the effects of the alternative information materials on several important aspects of radon risk perceptions. These include the processing of risk information, the updating of risk perceptions, and the development of a more intuitive understanding of radon risks.

Our baseline and followup surveys provide unique data to describe how people update their risk perceptions in response to new information because they track individuals' radon risk perceptions before and after they received their radon readings and the information materials. Such models provide insights about the rationality of risk perceptions that often cannot be found with cross-sectional surveys of individuals' risk perceptions that obtain only one appraisal of risk from each person.

We also evaluate the ability of homeowners to advise a neighbor about radon. Our analysis considers their responses to a question about whether a neighbor should take mitigation actions and how soon these actions should be taken. A wide range of radon levels are randomly assigned in this hypothetical but realistic question. The responses provide additional insight into the homeowners' ability to understand the risks from radon exposure. We supplement these analyses with examinations of the homeowners' performance in using the risk charts contained in the various radon information brochures.

Our overall findings suggest that brevity in risk communication is not a virtue. Brevity appears to increase subjective risk perceptions unnecessarily. The combination of numerical information and the colored risk chart improved people's ability to process risk information. Visual devices, such as the three colored columns used in the chart in the qualitative/command brochure, also appear to improve people's intuitive under-standing of radon risk concepts. Our behavioral models show a more rational risk perception process than that found by Weinstein, Sandman, and Klotz [1987].

4.2 CHANGES IN THE DISTRIBUTION OF PERCEIVED RISKS

Our information on risk perceptions is based on questions used in both the baseline and followup survey. Interviewers asked New York homeowners two questions about the risks they perceived from radon:

"Personal Risk" Question: Now, I'd like you to think about different risks you and your household face. For each type of risk that I read, please tell me how serious you think the risk is on a scale from 1 to 10. Number 1 on the scale is not at all serious and 10 is very serious . . . how serious are risks you (and your household) face from being exposed to radon?

"General Risk" Question: Compared to other health risks people face, how serious a health risk is radon--on a scale from 1 to 10 with 1 being not at all serious and 10 being very serious?

The 10-point scale was chosen to accommodate the needs of a telephone interview. Similar to that used by Johnson and Luken [1987], the simple scale is easily understood and provides sufficient range for people to express the risks they perceived from radon. Desvousges et al. [1987] used the exact 10-point scale in their study of perceived risks. It is in the same spirit as the format used by Weinstein, Sandman, and Klotz [1987].

The seriousness dimension of the scale includes both the likelihood of being exposed and the nature of the health outcome (lung cancer). The telephone interview format precluded the use of a risk ladder or risk circles (see Schulze, McClelland, and Coursey [1986] and Smith and Desvousges [1987]) to separate these two perception components.

Table 4-1 shows the frequency distributions for the two perceived radon risk questions, as well as responses for two other sources of risk--automobile accidents and hazardous waste exposure. Both the baseline (B) and followup (F) distributions are shown. For the personal risk from radon exposure, the most significant change in the distribution from the baseline to the followup interviews is the decrease in the "don't know" category of responses. This frequency of responses decreased from 25 percent to only 4 percent. The percentage of perceived risk responses at the low end of the scale also is much higher in the followup survey--46.8 percent of the homeowners perceived their personal risk from radon exposure to be low (i.e., two or less on the scale in the followup survey) compared to only 23.1 in the baseline survey.

The distribution of the general risk responses changed very little between the baseline and followup survey. The distribution also is quite distinct from the one for personal risks from radon exposure. In the followup interview, about 50 percent of the homeowners rated the general risk from radon 5 or higher, while only about 25 percent put their personal risk in those categories. The differences between the distributions of responses suggest that the respondents were able to distinguish between the two radon risk perception questions. The relative stability in the general risk distribution also implies that the homeowners updated their personal risks from radon exposure after receiving their radon readings and information materials.

TABLE 4-1. FREQUENCY DISTRIBUTIONS FOR PERCEIVED RISK BY SOURCES OF RISK: BASELINE vs. FOLLOWUP SURVEYS[a]

Seriousness of risk	Radon risk (personal)		Radon risk (general)		Automobile accidents		Hazardous waste	
	B	F	B	F	B	F	B	F
1	13.2	25.3	3.6	7.8	6.6	7.7	21.4	28.0
2	9.9	21.5	3.3	9.4	6.8	6.4	14.0	17.9
3	11.0	15.6	8.9	12.0	9.0	10.9	11.5	12.6
4	7.0	6.8	6.9	10.2	5.6	7.6	7.8	7.2
5	17.1	13.8	24.4	22.1	25.4	29.1	12.4	13.0
6	3.3	2.9	9.6	5.8	7.6	7.8	4.9	3.8
7	4.7	3.3	8.9	6.3	9.4	7.8	6.7	5.0
8	5.0	2.7	10.5	9.6	13.2	11.5	8.5	5.1
9	1.0	1.4	1.8	2.8	4.2	2.9	4.3	2.2
10	3.4	2.6	7.9	6.7	10.3	7.2	7.0	4.3
Don't know	24.5	4.1	14.3	7.3	2.1	1.2	1.6	1.1

Note: B = Baseline Survey
F = Followup Survey

[a] The frequencies may not add to 100 percent because of rounding error.

Since 6 months elapsed between the baseline and followup surveys, we cannot separate the effects of the information materials from the passage of time.* By comparing the perceptions of the seriousness of other risks, however, we have some informal evidence on risk perceptions that should be independent of the radon information materials. As shown in Table 4-1, the distribution of perceived risks for both automobile accidents and hazardous waste exposure are quite consistent in the two surveys. People also seem more confident of their perceptions for both of these risks. The "don't know" categories accounted for only about 2 percent in either the baseline or followup surveys.

When the various frequency distributions are compared, the large shift in responses out of the "don't know" category occurs primarily with the personal risk from radon exposure. While the percentage reporting "don't know" to the general risks posed by radon declines by one-half between the baseline and followup surveys, both the final percentage of "don't know" responses and the magnitude of the change for personal risk are more striking. After receiving the information materials, almost twice as many homeowners reported they did not know the general radon risk compared to the personal risk responses for that category. People seemed to be waiting for their radon readings to evaluate the severity of their personal risks from radon exposure.† After receiving the readings and the information materials, only 4 percent could not form perceptions of their risk from radon exposure.

Table 4-2 shows the frequency distributions for baseline and followup surveys grouped according to the type of radon information materials the homeowners received: the fact sheet, the four versions of the experimental brochures, and the EPA *Citizen's Guide*. Note that the distribution of perceived risk responses for the baseline survey is almost identical across the various types of information materials. This similarity results from our efforts to ensure that the information materials were independent of perceived risk responses in the baseline surveys. (See Appendixes A and B.)

When the responses to the followup survey are grouped according to the information materials received, there do not appear to be large differences in the distributions of perceived risks among the various types of information brochures or the fact sheet. While the distributions derived from the followup survey are different from the baseline distributions for each information

---

*There does not appear to be an extensive literature on the consistency of risk perceptions over time. The Wallsten-Budescu [1983] review indicates substantial work on the reliability of encoded risk perceptions, but does not discuss how perceptions might evolve over time. We also cannot control for people's access to and use of radon information in the general media. Over this time period there has been increased reporting about radon and its risks.

†In their debriefing, telephone interviewers remarked that, when asked the perceived risk question, people frequently commented, "Well I don't know. That's what I'm waiting for you to tell me with the monitoring results."

TABLE 4-2. FREQUENCY DISTRIBUTIONS FOR PERSONAL RISK FROM RADON BY INFORMATION TREATMENT: BASELINE vs. FOLLOWUP SURVEYS[a]

Seriousness of radon risk	FACT SHEET		COQUANT		CAQUANT		CAQUAL		COQUAL		EPA	
	B	F	B	F	B	F	B	F	B	F	B	F
1	13.2	24.3	14.7	30.0	12.2	24.2	14.2	26.8	12.2	20.6	11.6	26.0
2	9.5	19.7	10.0	22.3	9.5	25.2	9.8	21.7	10.5	21.6	10.1	19.9
3	11.8	16.2	12.3	14.3	10.9	15.7	9.5	12.9	10.1	19.2	10.5	15.9
4	8.1	6.0	6.3	7.0	6.5	6.1	8.5	7.5	5.2	9.4	6.1	6.1
5	16.3	14.4	15.0	12.0	21.1	15.3	17.3	14.9	17.4	12.2	15.9	13.4
6	3.9	4.0	4.3	1.7	1.4	1.7	2.7	2.7	4.2	3.5	2.5	3.3
7	3.0	4.0	6.0	1.0	4.4	2.0	4.8	4.4	7.7	3.5	4.7	4.0
8	5.1	3.2	6.7	3.3	5.4	1.7	4.1	3.4	2.8	1.7	5.4	2.5
9	0.7	1.1	0.7	1.7	1.4	1.4	1.0	0.3	1.4	2.1	1.1	2.2
10	3.9	2.0	1.7	2.3	3.4	3.1	1.7	2.7	3.5	3.1	6.1	3.3
Don't know	24.6	5.3	22.3	4.3	23.8	3.7	26.4	2.7	25.1	3.1	26.0	3.6

Note: B = Baseline Survey
F = Followup Survey

[a] The frequencies may not add to 100 percent because of rounding error.

treatment, comparing the results across types of information reveals no pronounced differences. However, as we show later in this chapter, there are significant differences in the effects of these materials that become apparent when statistical techniques are used to account for the differences in a homeowner's characteristics--for example, his age or education level. This distinction between interpretations of individuals' risk perceptions based on grouped data versus that derived from analysis of individual responses is consistent with other findings. Johnson and Luken [1987], for example, found that 56 percent of the individuals with high radon levels (in a relative sense) rated their risk as medium to low. Only for individuals with low objective risks did the majority indicate low subjective risks.

The Johnson and Luken findings for grouped data were more understandable when the analysis of posterior risk perceptions took account of differences in individuals' characteristics and their prior appraisals of risk. (see Smith and Johnson [forthcoming]). These studies highlight the importance of the classification scheme used to group individual responses. Because of the diversity in how individuals form their risk perceptions, some classifications can be misleading.

Weinstein, Sandman, and Klotz [1987] examined the frequency distributions for three subsets of their sample households, grouped according to their radon readings--less than 4 picocuries, 4 to 20 picocuries, and more than 20 picocuries. In each case they asked respondents to label their radon levels as "slight, moderate, or serious risk." Using the frequency distributions for these classifications with the three subsamples, they conclude that:

> . . . the label [risk classification] people used with respect to their own home was almost completely uncorrelated with their test results [radon readings]. (Weinstein, Sandman, and Klotz [1987], p. 17)

Weinstein, Sandman, and Klotz appear to examine only the frequency distributions and simple correlation coefficients between variables in reaching their conclusion. Further analysis of their data, which would account for differences in individuals' characteristics, could change their conclusions.

4.3 HOMEOWNERS' USE OF THE INFORMATION BROCHURES

The first step in understanding how individuals form risk perceptions is to evaluate how they used the information brochures explaining the relationship between their 2-month radon readings and the increments to their lifetime risks of lung cancer. Recent findings of Viscusi, Magat, and Huber [1986] emphasize the importance of examining how households process risk information. We obtained data on several aspects of how the respondent interpreted the risk information even though we were constrained by the format of a telephone interview. In this section we consider two issues:

- Whether the respondents correctly perceived the distinction between lifetime and annual risks

- Whether the respondents were able to use the risk charts provided in the NYSERDA and EPA information brochures.

Figure 4-1 displays the percentage of correct responses to a question that asked households about the relationship between lifetime and annual risks from radon exposure. Homeowners who received any of the information brochures did appreciably better in answering this question than those receiving only the fact sheet. Homeowners receiving the cajole/qualitative brochure demonstrated the best performance--83 percent answered this question correctly. Because this brochure used colored columns to illustrate the difference between lifetime risks and annual risks from radon exposure, we have some direct evidence that this visual device was effective in helping people understand the fundamental relationship between risk measures.

Evaluating whether households used the risk charts correctly is more difficult because the definition of a correct answer involves some judgment. This analysis is confined to homeowners who received any of the four NYSERDA brochures or the EPA *Citizen's Guide*. (The fact sheet did not contain a chart with risk information.) As shown in Figure 1-1, all of the NYSERDA brochures contained a colored risk chart that linked radon readings to lifetime risks. For homeowners receiving any of these brochures, we asked them if they recalled the color that corresponded to their radon reading. Because the EPA *Citizen's Guide* uses a different, more detailed risk scale with varying

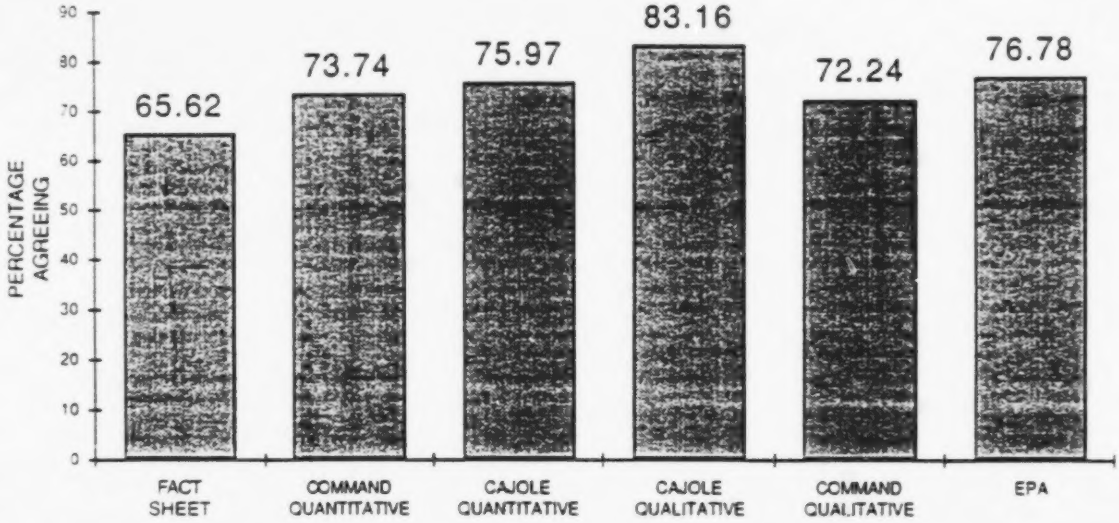


Figure 4-1. "The risk from one year of exposure to radon is much lower than the risk from lifetime exposure."

shadings rather than multiple colors, we asked these homeowners to indicate the approximate position of their readings in one of four areas on the chart.* Thus, the analysis of chart placement uses verbal reports of behavior, requires different recall tasks for the EPA and NYSERDA brochures, and involves a judgment on the definition of correct chart use.

Table 4-3 defines our criteria for correct responses and Figure 4-2 reports the frequency distributions for the correct use of the risk charts by brochure type. The differences in the percentage of correct responses among the NYSERDA brochures are not significant. Only about 50 percent of the households reported the correct color in each case. In contrast, the households receiving the EPA *Citizen's Guide* had a considerably lower success rate--only 3 out of 10 could recall which portion of the chart contained their readings. Although the two recall tasks differ, and our definition of correct responses may be more arbitrary for the EPA brochure, the observed difference in success argues for further analysis of the sensitivity of the results to how success is defined.

For now we use these definitions of correct use to examine the various factors that could account for homeowners' ability to recall the information from the NYSERDA risk charts more accurately than their counterparts who received the EPA *Citizen's Guide*. The analysis uses probit models with homeowners who recalled either their color or chart segment correctly being assigned a value of 1, and all others a zero. Table 4-4 defines the variables that are used in the rest of this chapter.

Table 4-5 presents the results for the likelihood that homeowners correctly use the NYSERDA risk charts. The definition does not distinguish between under- and over-statements. Each is treated as a comparable error. We estimate separate models for the EPA *Citizen's Guide* and the NYSERDA brochures, as well as models for various combinations of the sample. For each subgroup, we estimated separate models for homeowners with radon readings below 1 picocurie per liter and those with readings equal to or greater than 1 picocurie per liter. The table provides only one model in each case, but the general conclusions do not change for less detailed specifications.

The models for households with radon readings less than 1 picocurie (Models 1-2) are largely uninformative. Homeowners who had heard about radon before the baseline interview are more likely to use the NYSERDA risk chart correctly. Homeowners who felt that the concept of lifetime risk made it

---

*For those receiving a NYSERDA brochure: Which color on the radon risk chart did your radon reading correspond to?

Green	01	Orange	03	Other ________	05
Yellow	02	Red	04	Don't recall	94

For those receiving EPA's *Citizen's Guide*: Do you recall where on the radon risk chart your reading was? Was it?

a. Above the middle	01	d. At the bottom	04
b. In the middle	02	e. Don't know	94
c. Below the middle	03		

TABLE 4-3. DEFINITIONS OF CORRECT USE OF RISK CHARTS

Information brochure	Radon reading (R)	Color assignment or placement
NYSERDA	$R < 2$	Green
	$2 \leqslant R < 4$	Yellow
	$4 \leqslant R < 20$	Orange
	$20 \leqslant R$	Red
EPA	$R < 1$	Bottom
	$1 \leqslant R < 4$	Below the middle
	$4 \leqslant R < 20$	In the middle
	$20 \leqslant R$	Above the middle

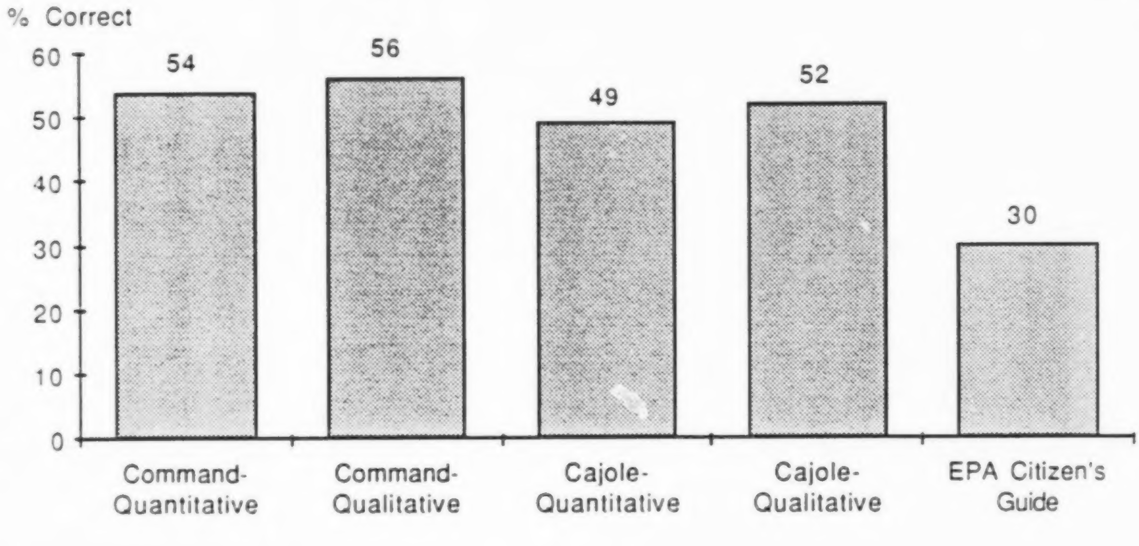


Figure 4-2. Frequency distributions for correct use of risk charts.

TABLE 4-4. DESCRIPTION OF SOCIOECONOMIC, ATTITUDINAL AND TECHNICAL VARIABLES

Variable/name	Description
AGE	Age of respondent.
EDUCATION	Years of education completed by respondent.
NEED HELP	A qualitative variable (0,1) for respondents who indicated on the baseline survey that they did not know which government agency to turn to for help and additional information on radon (= 1 if they do not know).
DOCTOR	Attitudinal variable (0,1) from the baseline survey = 1 if a respondent indicated that the statement "you always ask your physician a lot of questions or regularly read articles about health" described himself very or fairly well.
WAIT	Attitudinal variable (0,1) from the baseline survey = 1 if statement: "you usually wait until you have a lot of information before you decide to buy something new like an appliance" described himself very or fairly well.
MATH	Attitudinal variable (0,1) from the baseline survey = 1 if statement: "you are used to working with numbers or math because of your job or some other interests" described himself very or fairly well.
EXPERT	Attitudinal variable from the baseline survey = 1 if statement: "you often question information from experts or other authorities" described himself very or fairly well.
HEAR	Qualitative variable (0,1) from baseline survey = 1 if respondent had heard or read about radon in last 3 months.
TIME READING	The number of minutes the respondent reported reading the materials explaining how to interpret the radon readings (in the followup survey).
UNDERSTAND	Qualitative variable (0,1) from followup survey = 1 if the individual correctly located his reading on the risk charts provided in the brochures designed by the project or in the EPA *Citizen's Guide*.
COQUANT	Qualitative variable (0,1) = 1 if respondent received the brochure with command and quantitative design features.
COQUAL	Qualitative variable (0,1) = 1 if respondent received the brochure with command and qualitative design features.
CAQUANT	Qualitative variable (0,1) = 1 if respondent received the brochure with cajole and quantitative design features.
CAQUAL	Qualitative variable (0,1) = 1 if respondent received the brochure with cajole and qualitative design features.
EPA	Qualitative variable (0,1) = 1 if respondent received the EPA *Citizen's Guide*.
UNDLIFRISK	Qualitative variable (0,1) = 1 if respondent strongly agreed or agreed that the use of radon risk as a lifetime risk made it easier to understand personal radon risks.
UNDLIFMITIG	Qualitative variable (0,1) = 1 if respondent strongly agreed or agreed that the use of radon risk as a lifetime risk made it easier to decide on mitigation to reduce radon levels in the home.
AVERT	Qualitative variable = 1 if respondent has done or planned to do something to reduce household's exposure to radon.
ADJUST	Qualitative variable = 1 if individual adjusted his personal radon risk perception from the lifetime risks reported for the typical household.
SEX	Qualitative variable, male (= 1)
RACE	Qualitative variable, white (= 1)
SRISKF	The respondent's reported perception on a 1 to 10 scale of the seriousness of the personal risk facing his household from radon; this response was from the followup survey **after** receiving the reading and information materials.
SRISKB	The respondent's reported perception on a 1 to 10 scale of the seriousness of the personal risk facing his household from radon; this response was from the baseline survey **before** receiving any information.

TABLE 4-5. DETERMINANTS OF ABILITY TO USE RISK CHARTS: PROBIT MODELS[a]

Independent variables	Radon <1 NYSERDA treatments	Radon <1 EPA Citizen's Guide	Radon ≥1 EPA Citizen's Guide	Radon ≥1 NYSERDA treatments	Full sample		Combined NYSERDA and EPA	
					NYSERDA	EPA		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
INTERCEPT	-.4447 (-0.806)	-2.6079 (-2.256)	-.4409 (-0.421)	-.7746 (-1.763)	-.5366 (-1.600)	-.6422 (-0.932)	-.6430 (-4.541)	-.9159 (-3.103)
RADON	.1150 (0.425)	.7873 (1.454)	.0156 (0.446)	-.0543 (-3.897)	-.0633 (-4.789)	-.0483 (-1.438)	-.0596 (-4.849)	-.0600 (-4.871)
EDUCATION	.0424 (1.413)	.0424 (0.718)	-.0314 (-0.526)	.0399 (1.764)	.0358 (2.010)	-.0059 (-0.151)	—	-.0240 (1.497)
AGE	-.0002 (-0.050)	.0019 (0.174)	-.0101 (-1.124)	.0007 (0.189)	-.00004 (-0.012)	-.0055 (-0.854)	—	-.0010 (-0.383)
UNDLIFRISK	.2608 (1.268)	1.7389 (2.918)	.3127 (0.699)	.3297 (2.261)	.3243 (2.757)	.8322 (2.468)	.3970 (3.650)	.3949 (3.615)
DOCTOR	-.1693 (-1.011)	-.2465 (-0.816)	-.1118 (-0.353)	.1696 (1.410)	.0541 (0.563)	-.3299 (-1.614)	—	-.0093 (-0.107)
HEAR	.3298 (2.411)	.2547 (0.915)	-.0409 (-0.155)	-.0525 (-0.496)	.0896 (1.080)	.1025 (0.575)	—	.1034 (1.385)
COQUANT	.0664 (0.353)	—	—	.1156 (0.791)	.1030 (0.898)	—	.6367 (5.395)	.6393 (5.402)
COQUAL	.4772 (2.407)	—	—	.1147 (0.772)	.2421 (2.063)	—	.7722 (6.413)	.7770 (6.438)
CAQUANT	-.0079 (-0.042)	—	—	.0377 (0.258)	.0319 (0.279)	—	.5831 (4.965)	.5747 (4.881)
CAQUAL	—	—	—	—	—	—	.5270 (4.463)	.5330 (4.500)
TIME READING	-.0040 (-0.967)	-.0025 (-0.313)	.0049 (1.107)	.0019 (0.832)	-.0003 (-0.156)	-.0002 (-0.051)	-.0010 (-0.615)	-.0007 (-0.437)
SEX	-.2670 (-1.855)	.2521 (0.857)	.2858 (1.110)	-.1791 (-1.651)	-.1954 (-2.290)	.1841 (1.035)	—	-.1219 (-1.597)
n	389	95	137	602	991	232	1,223	1,223
Log (L)	-242.65	-57.269	-68.40	-401.69	-652.87	-140.75	-803.62	-799.59

[a] The numbers in parentheses below the estimated parameters are the ratios of the coefficients to their estimated asymptotic standard errors.

easier to understand personal radon risk are more likely to use the chart correctly in the EPA *Citizen's Guide*. The findings are quite different, however, for homeowners who received the NYSERDA brochures and had radon readings equal to or greater than 1 picocurie. Model 4 shows homeowners with higher radon readings were less likely to use the risk chart correctly.

We also consider whether general tendencies can be detected for the overall sample by eliminating the distinction by level of radon reading. Model 5 is estimated for all homeowners who received the NYSERDA brochures.* Model 5 estimates reinforce the results that showed homeowners with higher radon readings experiencing more difficulty with the chart. As the radon reading increases, a homeowner's answer for the NYSERDA risk chart is less likely to conform to our description of a correct use of the respective charts. These descriptions correspond to the standard assumptions underlying the lifetime risk estimates for radon, so this pattern could imply that households with higher radon levels are not using the charts correctly. Alternatively, it could be consistent with an increased incentive to adjust the risk estimates to reflect each individual's circumstances more accurately. While both interpretations are possible, we believe the results are more consistent with the increased likelihood of mistakes because the question asked for the color of an individual's reading not the color of his risk estimate. Moreover, as we show later in this chapter, these findings do not change when we include a qualitative variable to identify those households who stated they had adjusted their lifetime risk estimates.

The Model 5 results show several other significant determinants of correct chart use: education, sex, lifetime risk, and the qualitative variable, COQUAL, for homeowners who received the command/qualitative NYSERDA brochure. Generally, we find female homeowners with higher education levels, who agreed that the lifetime risk concept was useful and received the command/qualitative brochure, were more likely to answer the question correctly. The last of these variables, COQUAL, reflects the differential effect of the command/qualitative brochure over the omitted category which was cajole/qualitative. This is consistent with the frequencies reported in Figure 4-2 that showed homeowners receiving the command/qualitative brochure demonstrated the highest overall percentage of correct color placements. Unfortunately, the differential does not help to identify why homeowners' responses are inconsistent with what we defined as correct recall. The command versions of the NYSERDA brochure do not encourage adjustment of personal estimates of risk from radon. As a consequence, we would expect homeowners who received them to be least likely to adjust (and thereby make mistakes if they reported their adjusted risk estimates instead of the color of their radon readings). COQUANT has the next greatest numerical effect on the likelihood of "mistakes," but it is not a statistically significant variable. Therefore, it is not possible to extract a clear explanation of the difference in performance across brochures.

---

*Model 6 reports the results estimated for the homeowners who received the EPA *Citizen's Guide*. Because these results are uninformative, we concentrate on Model 5.

Models 7 and 8 in Table 4-5 provide a final comparison for the overall use of a risk chart. These models implicity assume that the correct usage of the EPA and NYSERDA charts is equivalent. While we noted that this assumption stretches the limits of comparison, it does offer an approximate appraisal of homeowners' performance in using the risk charts. Model 8 reports the detailed specification that we have used throughout this section and Model 7 presents a more limited specification that deletes all the socioeconomic variables that were insignificant, except time reading. We view this variable as a proxy measure of the individual's difficulty with the material.

Given the larger sample size, it is not unusual to find that Models 7 and 8 show more significant determinants of correct use of the risk charts. These results confirm the tendencies shown in the earlier models. Homeowners with higher radon readings are less likely to use the risk charts correctly, as we have defined correct use. Nonetheless, all of the NYSERDA brochures perform better than the EPA *Citizen's Guide* (the omitted category in these models). Thus, these probit results reinforce the frequency results in Figure 4-2 that showed only 30 percent of homeowners receiving the EPA brochure used its chart correctly. However, it is not surprising that homeowners found it easier to recall a color than a range on the chart. These models also show that homeowners who thought that the lifetime risk concept was helpful are more likely to use the risk charts correctly.

It is possible that homeowners may have reported their answers after they had adjusted their risks. One approach for testing whether homeowners reported the colors corresponding to their adjusted risk is to examine the relationship between correct chart use and the qualitative variable for reported adjusted risk. To test this hypothesis, we estimated probit models shown in Table 4-6 combining the correct use of the NYSERDA chart and the EPA chart and then a separate model on the NYSERDA chart alone. The adjustment variable does not have a statistically significant effect on the correct use of the chart in either case.

Overall, our findings imply that the format used in presenting risk information affects the homeowners' ability to use that information. The colored columns helped homeowners develop an intuitive understanding of lifetime risk. The colored risk charts also made it easier for homeowners to recall the location of their radon reading than the EPA chart. But these preliminary findings suggest that the information transfer was not ideal. Only one-half of the homeowners recalled their correct color. Individuals with higher readings were more likely to make mistakes according to our definition. Whether the mistakes reflect adjustments that the cajole versions of the NYSERDA brochures sought to encourage merits more attention. Alternatively, something in how homeowners process the chart information could cause them to discount (or reject) "bad news" associated with higher readings. This hypothesis merits evaluation as well. Future research also should distinguish the type of mistake--overstatements versus understatements of risk--and seek to evaluate the source of these mistakes. If the brochures designed to promote adjustment lead to "mistakes" that are understatements by our conservative criteria and these reductions appear warranted based on the homeowner's circumstances, then these findings would not reflect the failure of

TABLE 4-6. PROBIT MODELS FOR CORRECT USE OF RISK CHARTS

Independent variables	Combined sample NYSERDA and EPA	NYSERDA sample only
INTERCEPT	−1.0307 (−2.367)	−.7597 (−1.593)
RADON	−.0510 (−4.399)	−.0542 (−4.350)
COQUAL	.7027 (6.304)	.0426 (0.399)
COQUANT	.5741 (5.235)	.1761 (1.622)
CAQUAL	.5275 (4.825)	—
CAQUANT	.4830 (4.416)	−.0485 (−0.454)
EDUCATION	.0367 (2.498)	.0490 (2.986)
AGE	.0118 (0.740)	.0155 (0.871)
AGE^2	−.0001 (−0.881)	−.0002 (−0.989)
HEAR	.0937 (1.345)	.0465 (0.601)
ADJUSTED RISK	−.0006 (−0.006)	.0124 (0.123)
TIME READING	−.0014 (−0.878)	−.0007 (−0.394)
DOCTOR	.0291 (0.365)	.1079 (1.227)
WAIT	.0012 (0.013)	−.0493 (−0.490)
n	1,394	1,126
Log (L)	−922.74	−748.81

information programs. Rather, they would illustrate that the sample respondents had processed the adjustment informtion in the brochures, thus performing sophisticated personal risk assessments.

4.4 A BEHAVIORAL MODEL FOR RADON RISK PERCEPTIONS

This section tests the ability of a Bayesian model to explain the process of how households form their risk perceptions. The Bayesian model assumes that the mean of distribution of an individual's sentiments after new information is received (the posterior distribution) is a weighted average of the mean of the distribution of an individual's beliefs before the new information is received (the prior distribution) and a sample mean. New information is treated like the sample mean in the Bayesian updating rule--i.e., it indicates that the prior distribution characterizing an individuals' beliefs should be modified.

Viscusi and O'Connor [1984] used this basic framework to describe how people form their subjective risk perceptions. Their analysis considered chemical workers' risk perceptions for their actual jobs and for a hypothetical change in those jobs that would require them to handle a specified new chemical. They used several types of labels to describe the chemicals that were associated with the hypothetical change. The workers were asked about their perceptions of the job risks before and after reading the labels. This process provided information on the prior and the posterior risk assessments. The labels were assumed to convey information to the workers that allowed them to act as if they had received a sample estimate of the risk. In their model, the implicit sample risk is derived from the relationship between the reported prior and posterior risks--it is not observed.

Viscusi and O'Connor [1984] found that the Bayesian model explained the process of how workers formed their perceptions. Smith and Johnson [forthcoming] found similar support for an extension of this model using perceived radon risks along with individuals' characteristics. Their analysis was based on a sample of Maine households who received identical brochures with their radon readings.

Neither study offers an ideal test of the Bayesian framework. The Viscusi-O'Connor analysis was based on a hypothetical situation, while Smith and Johnson had to rely on a retrospective appraisal of the respondents' subjective risks before the new information (i.e., their radon reading) was received. Our study design avoids both problems. It allows us to elicit information about each individual's perception of the personal risk radon exposure twice--before the reading and information materials were available, and after the information had been distributed. The circumstances facing these households involve actual risks arising from the radon in their homes. By altering the way the radon risk was explained to each household, we can determine whether the type of information, as well as an individual's characteristics, affect the process of updating risk perceptions

This last issue has been an important element in our research design. The economics and psychology literature on lay persons' risk assessment practices and behavior in the presence of risk clearly indicates that this process must be described within a behavioral model of individuals' decisions. This makes it reasonable to expect that the weights an individual would attach to each type of information would depend on how he values the outcomes at risk, as well as how he perceives the relative precision of the new information in relation to his prior beliefs.*

Equation (4.1) describes the basic Baysian model for radon risk perceptions.

$$SRISKF_j = a + b\ SRISKB_j + c\ Radon_j + \sum_{k=1}^{L} d_k X_{kj} + e_j \tag{4.1}$$

where

$SRISKB_j$, $SRISKF_j$ = the subjective risk perceptions of individual j at the time of the baseline and followup surveys, respectively.

$Radon_j$ = individual j's radon reading

X_{kj}, (k=1,L) = the set of independent variables, including the qualitative variables (COQUANT, COQUAL, CAQUANT, CAQUAL, EPA) describing the type of information individual j has received, as well as other characteristics of each respondent.

e_j = a random error

a, b, c, d_k = the parameters of the model.

Table 4-7 reports three specifications for this basic model estimated with ordinary least squares (OLS). These models are representative of a wider range of results with similar estimates. Model 1, the simplest version, assumes that the radon reading is the only source of new information. Model 2 includes the information brochures (with the fact sheet the omitted category) along with the radon reading. Model 3, the more general model, includes prior risk perception information and individual characteristics as potential determinants of perceived risk. The estimated effects for prior risk perception and radon reading are quite stable across alternative specifications of the more general version of the Bayesian model. Both variables have significant estimated parameters.

Generally the models do not explain a lot of the variation (as measured by R^2) in our index of posterior risk perception. There are several reasons for not devoting much attention to R^2 as an index of goodness of fit for these relationships. First, the models are estimated for a categorical variable--

---

*See Smith and Johnson [forthcoming] and Smith and Desvousges [1986] for a more detailed development of this point. In the first case, the analysis is used to propose a general, reduced-form model for describing the risk perception process.

TABLE 4-7. RADON RISK PERCEPTION MODELS

Independent variables	Models		
	1	2	3
INTERCEPT	.1591 (14.137)	.1798 (12.082)	.4472 (7.034)
SRISKB	.2192 (9.280)	.2176 (9.215)	.1840 (7.440)
RADON	.0135 (5.403)	.0147 (5.706)	.0132 (4.286)
AGE	—	—	−.0008 (−1.485)
DOCTOR	—	—	.0331 (2.055)
UNDLIFRISK	—	—	.0003 (0.013)
TIME READING	—	—	.0006 (1.922)
YEARS AT ADDRESS	—	—	−.0001 (−0.642)
HEAR	—	—	−.0033 (−0.242)
SEX	—	—	−.0029 (−0.203)
EDUCATION	—	—	−.0108 (−3.804)
UNDLIFMITIG	—	—	.0380 (1.551)
RACE	—	—	−.1099 (−3.041)
MATH	—	—	.0040 (0.281)
EXPERT	—	—	.0060 (0.388)
COQUANT	—	−.0505 (−2.407)	−.0900 (−2.779)
COQUAL	—	−.0095 (−0.438)	−.0576 (−1.178)
CAQUANT	—	−.0539 (−2.541)	−.0958 (−3.009)
CAQUAL	—	−.0296 (−1.382)	−.0705 (−2.116)
EPA	—	−.0057 (−0.260)	−.0521 (−1.530)
UNDERSTAND * RADON	—	—	.0019 (0.402)
n	1,465	1,465	1,417
R^2	.074	.081	.100
F	58.649	18.400	7.798

seriousness of personal risk based on a 1-to-10 scale. Although the variable has been rescaled to the 0 to 1 interval, it is not continuous and offers at best an ordinal index of probability. Based on the extensive literature on R^2 for models with qualitative dependent variables, it will not perform in the same way that it would with continuous random variables. Second, even if the first problem were not present, R^2 is generally low in cross-sectional samples.

Finally, the risk perception process is a "noisy" one. To be able to ask about people's risk perceptions we have introduced problems with our models (i.e., created an ordinal variable, bounded between 0, 1) in order to enhance our ability to elicit their risk perceptions in a telephone interview. This will make it more difficult to interpret the weights in the Bayesian model. They reflect the index used to make risk perceptions more easily reported as well as the correct perceptions. The discrete nature of our index makes it difficult to predict actual risk perceptions accurately. Nonetheless, our findings suggest that the noise in the perceived risk index has not impaired our ability to evaluate potential determinants of those perceptions.

Several overall conclusions hold across all models:

- The models provide support for the Bayesian formulation of the risk perception process: respondents updated their risk perceptions in a rational fashion. There was a strong positive relationship between the radon reading and respondents' risk perceptions stated in the followup survey. This contrasts sharply with the Weinstein, Sandman, and Klotz [1987] findings noted earlier.

- Information treatments significantly affected risk perceptions, with the NYSERDA brochures leading to lower implicit sample risks for a given radon reading than the fact sheet.

- The quantitative versions of the NYSERDA brochures reduced perceived risk relative to the fact sheet and had the largest effects.

- The EPA *Citizen's Guide* had a negative estimated coefficient, implying a lower implicit sample risk, but it was not significant.

- Individual characteristics affect how homeowners updated their risk perceptions. This is especially true for education, the qualitative variable indicating respondent's interest in health, and race.

The information effects are included in the Bayesian model using qualitative variables. By assuming these qualitative variables shift the intercept of the model, we imply that the information treatment affects a respondent's perception of the risk message contained in the information materials. We refer to this perception as the "sample risk" because it is analogous to new information obtained by sampling from a probability distribution. To illustrate this point, consider a simple description of the model that assumes the posterior risk perceptions, SRISKF, are a weighted average of prior risk perceptions, SRISKB, and the perceived risk message in the information (i.e, the sample) provided to the individual. We shall designate this as SRISKS. Because the weights sum to one, the basic model must satisfy two equations:

$$\text{SRISKF} = W_B \text{ SRISKB} + W_S \text{ SRISKS} \tag{4.2}$$

$$1 = W_B + W_S \ . \tag{4.3}$$

As in the Viscusi-O'Connor [1984] model, the variable SRISKS is not observed. However, the Bayesian model implies that the respondent's interpretation of the radon reading and information materials leads to the formulation of a value for SRISKS. For the simple form, we estimate a model as in (4.4) below

$$\text{SRISKF} = \alpha_0 + \alpha_1 \text{SRISKB} \ . \tag{4.4}$$

This formulation implies that the sample risk each individual imputed to the new information was constant (i.e., $\alpha_0 = W_S\text{SRISKS}$). By introducing variables that shift the intercept for a given level of SRISKB, we allow the implicit sample risk to be a function of the information materials that were received. To include an individual's characteristics, as well as the information materials, complicates matters. If I designates an information variable, and C a variable relating to an individual's characteristics, the extended model is given by (4.5) and the implicit sample risk and its weight by (4.6)

$$\text{SRISKF} = \alpha_0 + \alpha_1 \text{ SRISKB} + \alpha_2 I + \alpha_3 C \tag{4.5}$$

$$W_S \text{ SRISKS} = \alpha_0 + \alpha_2 I + \alpha_3 C \ . \tag{4.6}$$

To recover an estimate of SRISKS, we used the restriction on the weights for the two types of information affecting the posterior risk perceptions. α_1 is an estimate of W_B. Using (4.3) and (4.4) we can estimate W_S as $1 - \alpha_1$ and thereby recover an estimate of SRISKS from (4.6) as:

$$\text{SRISKS} = \frac{\alpha_0 + \alpha_2 I + \alpha_3 C}{1 - \alpha_1} \ . \tag{4.7}$$

This implies that all variables specified to enter in additive form (i.e., not interacted with the prior risk, SRISKB) will affect the model's estimate for the SRISKS. Using the general form of our model as given by Equation (4.1), the relationship is:

$$\text{SRISKS}_j = \left(\frac{a + c \text{ RADON}_j + \sum_k d_k X_{kj}}{1 - b} \right) \ . \tag{4.8}$$

To illustrate, consider the estimates in Model 2 of Table 4-7 and assume the radon level is at the EPA action guideline of 4 picocuries per liter. Households receiving the fact sheet, at this radon level, would attribute an implicit sample risk index of .305 to the information they received. In contrast, those receiving either quantitative version of the NYSERDA brochures would attribute about a 20 percent lower risk to that information. Undoubtedly, this specification is too simplistic. Both the information treatments received and the respondents' characteristics should be considered. In principle, we would have a different implicit sample risk for each respondent. We have estimated these risk messages and use them in our overall evaluation in Chapter 6.

Before concluding this section, we can outline some possible refinements of the analysis. First, our estimates may be biased because of selection effects caused by omitting the respondents who answered "don't know" to either the baseline or their followup risk-perception questions. This decision was necessary for estimating the Bayesian model. At the beginning of this chapter, we noted that the "don't know" responses are an important segment of the sample, accounting for about 25 percent of the sample. Moreover, the change from the "don't know" response to a specific risk perception in the followup survey represents one of the most important responses to the information provided. Some preliminary probit models for the "don't know" response in the baseline survey indicate a relationship between that response and various characteristics of the respondents. This could be a source of bias in our estimates of the effects of these variables and, potentially, the radon and information variables.

A second issue involves changing the type of estimation approach. For example, the perceived risk variable is censored at zero and one because of the question design. However, our statistical tests for significance of the parameters with OLS assume that this variable is normally distributed. A maximum likelihood estimator is warranted to account for this feature of the dependent variable, but our previous experience with even smaller samples suggests that the nature of our results is unlikely to change. However, the numerical values of the estimated coefficients will change. This implies the need for some caution when the magnitude of the imputed risks is considered. These econometric issues represent an important source of qualifications to these findings. However, we do not think reestimation with the appropriate adjustments would substantively change our overall conclusions.

4.5 MORE EVIDENCE ON THE PLAUSIBILITY OF HOUSEHOLDS' SUBJECTIVE RADON RISKS

Additional evidence on the plausibility of homeowners' perceived risks from radon, and the effect of information on these perceptions, can be gained from a somewhat different perspective: assessing the ability of households to advise others about potential risks from radon. Moving away from a homeowner's personal risk allows us to consider a wider range of potential risks than was possible with the actual radon readings. If people correctly processed the information from the various information materials, they should be able to inform others about how serious the risks would be from a particular level of radon exposure.

We asked each household to describe how they would advise a family in their neighborhood, using the following question:

> Now, I'd like to ask you about advising a family in your neighborhood on whether to reduce radon levels in their home. Suppose your neighbors were told that their reading for the winter months was (READ CIRCLED NUMBER) 3 4 5 8 10 15 20 30 50 75 picocuries per liter. Would you advise them to reduce their radon levels?

A radon level was randomly assigned to each respondent.

At this point, our analysis of these responses has considered two issues--the advice to act and the proposed timing for action. We used a simple probit model to describe the likelihood of a homeowner advising a neighbor to act. Independent variables in the model include the radon reading in the neighbor's home (NRADON), the information materials the homeowner had received, and a selected set of variables that were important in the previous probit model. Our main hypothesis is a simple one: If people understand the risks from radon, the likelihood of advising neighbors to act should increase with the level of radon.

To analyze how soon the homeowner thought his neighbor should act, we specified an appropriate response for the timing based on the timing of actions described in the brochures. The probit model considers whether homeowners gave appropriate advice to their neighbors on how soon they should act (TIMEOK = 1). The probit model includes the radon reading in the neighbor's home, the information treatment and a selected set of other variables describing the individual's understanding of risk and socioeconomic characteristics.

The models for TIMEOK face the same problems as our analysis of homeowners' use of the risk charts with their personal radon readings. They assume each individual used the standard situation described in the brochures, even when the cajole variant of these brochures encourages adjustment for personal circumstances. In addition, we believe the definition of appropriate timing based on what is in the brochures is more arbitrary. There was no specific schedule presented, so there is more scope of individual adjustment. For these reasons we have used "appropriate" to describe the responses, rather than "correct." Table 4-8 lists the criteria for the appropriate time schedule for mitigation. It is based on our judgmental interpretations of the EPA Guidelines.

Our basic hypothesis for the "appropriate" timing responses is: The likelihood of an appropriate answer should increase with the level of radon. While there could be legitimate disagreement about the criteria at low or moderate radon levels, almost everyone agrees that at very high levels people should take actions as soon as possible. In further investigations, it would be possible to examine other criteria to see if the results changed. Overall, the results in Table 4-9 strongly support our hypotheses: The higher the level of radon depicted in the neighbor's home, the more likely homeowners are to recommend action be taken, and the more likely they are to correctly advise their neighbor on how soon something should be done.

TABLE 4-8. DEFINITION OF APPROPRIATE TIME SCHEDULE FOR MITIGATION IN ADVICE TO NEIGHBOR

Radon reading (R)	Timing
$R \leqslant 4$	Within the next few years
$4 < R < 20$	Within the next year
$20 \leqslant R \leqslant 30$	Within several months
$30 < R \leqslant 50$	Within several weeks
$50 < R$	As soon as possible

TABLE 4-9. PROBIT RESULTS ON HOMEOWNERS' RECOMMENDATIONS TO NEIGHBORS

Independent variables	Should neighbor mitigate? (NMITIG) Model 1	Model 2	Did the homeowner correctly interpret severity? (TIMEOK)
INTERCEPT	.2011 (0.948)	.3298 (1.301)	– 1.9728 (– 5.785)
NRADON	.0065 (3.933)	.0064 (3.922)	.0250 (13.697)
EDUCATION	.0277 (1.881)	.0240 (1.617)	.0437 (2.277)
AGE	—	– .0025 (– 1.026)	– .0061 (– 1.467)
TIME READING	—	.0016 (0.873)	.000003 (0.001)
HEAR	.1110 (1.587)	.1125 (1.621)	.0379 (0.415)
YEARS			– .0030 (– 0.609)
DOCTOR	—	.0300 (0.382)	– 0.392 (– 0.381)
COQUANT	– .5036 (– 3.252)	.1307 (1.123)	.1481 (0.634)
COQUAL	– .5719 (– 3.710)	.0526 (0.454)	.0985 (.0419)
CAQUANT	– .5875 (– 3.935)	.0121 (0.167)	.1635 (0.697)
CAQUAL	– .6757 (– 4.265)	.0082 (0.073)	.5316 (2.296)
EPA	– .7492 (– 4.731)	– .0773 (– 0.669)	.1569 (0.645)
UNDLIFRISK	.4063 (3.416)	— —	– .1847 (– 1.094)
UNDLIFMITIG	.3939 (3.354)	— —	.0840 (0.462)
Log (L)	– 866.58	– 884.36	– 496.17
n	1,726	1,726	1,312

Several other interesting findings can be gleaned from the advise-neighbor results. All else equal, homeowners who think lifetime risk is a useful way to understand the risks from radon are more likely to recommend that their neighbors take action. The same is true for those who think that mitigation decisions are easier to understand with the lifetime risk concept. More educated homeowners also are more likely to recommend actions.

Two probit models are presented for the "advise neighbor" decision because we found that our conclusions were quite sensitive to the final specification. Comparing Models 1 and 2 in Table 4-9, we see that our conclusions on the importance of information treatments depend on whether the two qualitative variables--based on whether homeowners felt that the lifetime risk concept was helpful to their evaluation of risk and mitigation decisions--were included. There were both sign changes and no significant relationships between the information variables and the likelihood of advising a neighbor to take some action when these variables were dropped from the model. Both of these variables were significant determinants of the likelihood of a homeowner's recommending action, so the interrelationship is understandable, but surprising because of the striking nature of the changes. We would expect that the information materials affected a homeowner's understanding of these lifetime risk concepts too. Nonetheless, this sensitivity is an issue that deserves further attention.

The probit results for recommendations on how soon a neighbor should take action, which are not sensitive to model specification, provide one interesting contrast to the results on recommending mitigation. Homeowners who received the cajole/qualitative version of the NYSERDA brochure are more likely to make recommendations consistent with our definition of the appropriate timing. This version, which uses the three colored columns to illustrate the difference between annual risks and lifetime risks, also was more effective in helping people make the fundamental distinctions in key risk concepts. (Recall Figure 4-1.) Our results imply that this information format and tone were more effective than the command versions, which gave explicit action guides. Although the cajole/quantitative version gave the same information, the numerical table format appears to have been less effective in helping people understand lifetime versus annual risks.

Additionally, the level of the radon reading is a positive and significant influence on the likelihood of a correct answer, which is consistent with our hypothesis. While age was not a significant determinant, it does reduce the probability of a correct recommendation. In contrast, higher levels of education increase the probability. This is consistent with our earlier results.

4.6 CONCLUSIONS

In this chapter, we have undertaken several complementary analyses to address the fundamental question that Milton Russell [1986] raised, "Do the right people worry and the others stop?" Based on the results from the Bayesian models that view people as systematically updating their risk perceptions, and the ability of homeowners to advise their neighbors about radon, we find that the answer is "yes." Unlike Weinstein, Sandman, and Klotz [1987] who found no simple association between perceived and technical risks, our results show people's perceptions generally change in the appropriate direction in response to information on radon risks. While the direction of change is consistent with rationality, we also find that the adjustments are far from perfect, with some groups having more difficulty assessing their risks from radon. Older people and less educated people were less likely to process risk information correctly. The same was true for homeowners who received the fact sheet about radon.

More specific conclusions from this chapter include:

- People used both the reported radon reading and information materials in forming their current risk perceptions.

- Households updated their risk perceptions systematically in response to new information. A simple Bayesian model that describes the relationship between current subjective risk perceptions, earlier perceptions, and information performed quite well. The information brochures substantially affect the updating process: people who received the quantitative versions of the brochures have lower subjective risk perceptions when compared to those of people who received the fact sheet. The EPA *Citizen's Guide* and the qualitative versions of the NYSERDA brochures did not change the updating process over that impled by the fact sheet.

- People were able to offer their neighbors sound advice about mitigation. For higher radon levels, they were more likely to recommend actions be taken, and they were likely to recommend they be taken in the "appropriate" timeframe.

- People who received the cajole/qualitative brochure, which included a risk chart with three colored columns to differentiate lifetime and annual risk, were better able to distinguish these risk concepts. They also were more likely to recommend that their neighbors take mitigation actions in the appropriate timeframe. Apparently, these people were able to use what they learned in forming the advice they would give to others.

- The results show homeowners had some difficulty processing the information in the risk charts. Homeowners with higher radon levels were more likely to recall the location of their radon reading incorrectly than homeowners with lower levels. Homeowners receiving the EPA *Citizen's Guide* also were more likely to incorrectly recall their location. These results are preliminary because our analysis has not distinguished whether the mistakes were overstatements or understatements.

4.7 REFERENCES

Desvousges, William H., Richard W. Dunford, James Frey, Howard Kunreuther, Roger Kasperson, and Paul Slovic, 1987, *High-Level Nuclear Waste Repository Risks: Focus Group Findings and Implications for Surveys,* Report prepared for Mountain West and the Nuclear Waste Project Office, State of Nevada, Research Triangle Institute, Research Triangle Park, North Carolina, January.

Johnson, F. Reed, and Ralph A. Luken, 1987 "Radon Risk Information and Voluntary Protection: Evidence from a Natural Experiment," *Risk Analysis*.

Russell, Milton, 1986, Speech to Workshop on Reporting of Health Risk Information by Television, Columbia School of Journalism, New York, New York, April 22.

Schulze, William D., Gary H. McClelland, and Don L. Coursey, 1986, "Valuing Risk: A Comparison of Expected Utility With Models from Cognitive Psychology," Unpublished manuscript, University of Colorado, Boulder, Colorado.

Smith, V. Kerry, and William H. Desvousges, 1986, "Information, Risk Perception and Environmental Policy: The Case of Radon," paper presented to Association of Environmental and Resource Economists, New Orleans, December.

Smith, V. Kerry, and William H. Desvousges, 1987, "An Empirical Analysis of the Economic Value of Risk Changes," *Journal of Political Economy*, Vol. 95, No. 1, January/February, pp. 89-114.

Smith, V. Kerry, and F. Reed Johnson, forthcoming, "How Do Risk Perceptions Respond to Information? The Case of Radon," *Review of Economics and Statistics*.

Viscusi, W. Kip, W. A. Magat, and Joel Huber, 1986, "Informational Regulation of Consumer Health Risks: An Empirical Evaluation of Hazard Warnings," *Rand Journal of Economics*, Vol. 17, Autumn, pp. 351-65.

Viscusi, W. Kip, and Charles J. O'Connor, 1984, "Adaptive Responses to Chemical Labeling: Are Workers Bayesian Decision Makers?" *American Economic Review*, Vol. 74, December, pp. 942-56.

Wallsten, Thomas S., and David V. Budescu, 1983, "Encoding Subjective Probabilities: A Psychological and Psychometric Review," *Management Science*, Vol. 29, February, pp. 151-73.

Weinstein, Neil D., Peter M. Sandman, and M. L. Klotz, 1987, *Public Response to the Risk from Radon, 1986*, Final report to Division of Environmental Quality, New Jersey Department of Environmental Protection, Rutgers University, January.

CHAPTER 5

THE DEMAND FOR RADON INFORMATION

5.1 INTRODUCTION

This chapter evaluates the demand for radon information using two complementary approaches. The more analytical approach uses a discrete choice model to estimate the demand for the services of a radon diagnostician. In the followup survey, we asked respondents whether they would pay for the services of someone who would diagnose the source of their radon problems and make mitigation recommendations. The questions required a yes/no answer to the offer of these services for a price that was randomly assigned across respondents. Such a question illustrates the value of hypothetical questions when they address important issues in ways that are relatively easy for respondents to answer.

The second approach for analyzing radon information addresses alternative radon communication channels. This approach combines descriptive and analytical techniques in assessing homeowners' expressed preferences for longer brochures, town meetings, and other communication channels. This analysis also follows up on groups of respondents who did not know where to turn for more information in the baseline survey and tracks the sources of information respondents have used.

5.2 RADON INFORMATION DELIVERY MODEL

The principal agent model provides a convenient framework for addressing the importance of radon information delivery. Economic applications of the principal agent model usually involve situations where consumers have incomplete information and must rely on an expert's services.* Analysts have used the model to understand how people negotiate arrangements for the sale of houses, sophisticated products, auto repair, and health services. All these situations involve incomplete or very technical information that complicates and may even preclude a consumer's evaluation of the commodity or service. For example, the principal (patient) constructs his demand for health services based on the advice provided by the agent (the physician). The consumer recognizes that the agent may provide both essential information for his demand decisions and the services themselves. Consequently, the theoretical literature focuses on mechanisms to enhance the compatability of incentives for the principal and agent that would ensure efficient resource allocation decisions.

---

*An outline of the theoretical features of this type of model can be found in Ross [1973]. It has been suggested for a wide array of applications. One of the earliest was Feldstein's [1974] proposal that it be used to describe the physician-patient relationship in the demand for medical services.

We adapted the principal agent framework to investigate the importance of how radon information is delivered to the household. We developed an ideal agent: a State-licensed radon expert who would provide the homeowner (the principal) with information on the source of his radon problems, help plan mitigation, and assist in finding a qualified contractor. The diagnostician, however, would have no economic stake in the homeowner's decision--he would recommend actions based on a flat fee, which would be paid regardless of whether the homeowner decided to follow the recommendations. An independent contractor would actually implement the decisions, not the diagnostician. Separating the diagnostician's role from actual mitigation eliminates any incentive for strategic behavior. This separation also eliminates the need to impose a sharing of the risks between the homeowner and diagnostician that could arise from the latter's actions. (See Stiglitz [1974] and Shavell [1979].)

The followup survey gave homeowners a hypothetical opportunity to purchase the services of the ideal information agent--the radon diagnostician. The interviewer described the diagnostician as follows:

> Suppose a qualified and State-licensed person in your area would diagnose how radon was getting into your home. He would also help you decide what to do about it and where to find a qualified contractor. If the full cost of this service was [one of the following values was randomly selected and read to each respondent: $25, $50, $100, $150, $250, $400], would you purchase the service?

Compared to open-ended valuation questions, this type of closed-ended, yes/no format offers a more familiar choice situation and may require less information processing. It is also more amenable for use in a telephone interview.* Recently, analysts have used similar questions in a wide range of successful applications. (See Bishop and Heberlein [1979], Hanemann [1984], and Cameron and James [1987] for further discussion.)

The responses to such questions can be analyzed in many ways. The most common assumes that consumers compare the level of utility of not purchasing the service and not paying the fee with the utility of paying the fee and getting the service.† In technical terms, the process involves describing the outcome of the choice process as stochastic indirect utility functions that characterize consumer well-being under each decision. The random component may enter the utility function for various reasons. For example, people's incomes (or any other factors that affect preferences) may be uncertain when the decision must be made. Alternatively, the analyst may introduce the stochastic element because of the inability to observe all factors that influence an individual's decisions. This could cause the parameters in the constraints to individual choices--prices, incomes, or timing--to be specified incorrectly. Incomplete information on an individual's characteristics that affect choices also may account for the random errors. Measurement errors are another possible source of the stochastic elements, as are combinations of any of these reasons.

---

*See Smith and Desvousges [1986], especially Chapter 6.

†The remainder of this section contains the more technical details of the model. Readers interested in our findings can turn directly to page 5-5.

For the analysis of radon diagnostician choices, we assume that a person's utility function includes two parts: $u_i(\bullet)$ designates the observable part and $e_i(\bullet)$ the stochastic part. We also assume that these stochastic terms (e_i) arise from both measurement error and our inability to completely observe all of the individual's characteristics (or constraints) that might affect the decision. This second assumption simplifies how we interpret measures of people's well-being derived from the estimates of the indirect utility function.

For this analysis, we assume linear, state-dependent utility functions with two possibilities:

State	Utility
Purchase services of radon diagnostician	$U_p = u_p + e_p = a_p + b_p(y-c) + d_pZ + e_p$
Refuse to purchase services of radon diagnostician	$U_R = u_R + e_R = a_R + b_Ry + d_RZ + e_R$.

y designates household income; c the proposed fixed fee for the agent's services; Z is a vector of variables that influence the household in one or both states; a_i, b_i, and d_i are parameters of the two utility functions. The exclusion of particular variables in either state-dependent utility function can be handled by specifying that elements in the parameter vectors d_p or d_R are zero.

Applying this model to the choice of a radon diagnostician's services, a homeowner decides whether to purchase the service by comparing the total utility in each of the two possible states as in Equation (5.1). He will purchase the service if his utility is greater for the purchase

$$u_p(.) + e_p(.) - (u_R(.) + e_R(.)) > 0 \quad . \tag{5.1}$$

By replacing the nonstochastic component $u_i(\bullet)$ with a linear function, we can describe the probability of a household purchasing the services of the hypothetical radon diagnostician as in Equation (5.2)

$$\text{Prob (purchase diagnostic services)} = \text{Prob } (e_R - e_p < \alpha + \beta\, y - \gamma\, c + \theta\, Z) \tag{5.2}$$

where

$\alpha = a_P - a_R$

$\beta = b_P - b_R$

$\gamma = b_P$

$\theta = d_P - d_R$.

Assuming that $e_R - e_P$ follows an independent standard normal distribution (or a normal with variance, σ^2, when we are interested only in estimating the parameters of $u_i(.)$ relative to σ), we can use the probit technique to estimate the parameters of the nonstochastic indirect utility functions. Then we can use these parameters to estimate the maximum amount homeowners would pay for the radon diagnostician service.

Assuming a linear nonstochastic utility function in this discrete choice framework simplifies the interpretation of welfare measures. Hanemann [1984] defines three possible welfare measures:

- The expected value derived from the distribution for the maximum willingness to pay
- The value of the payment for the services that would equate expected utilities under the two decisions
- The payment that would make the individual indifferent, in probability terms (probability = 1/2), between having the service or not.

All three of these measures are equivalent for a linear utility function. This would not be true for nonlinear specifications.

A fourth welfare measure can be defined by interpreting the consumer's decision process differently. Instead of assuming homeowners compare the values for the indirect utility function in making their choices, we could assume the choice is based on a comparison of the inverse demand function with the stated price. (See Cameron and James [1987].) This approach generally leads to a different estimation approach, but the linearity assumption implies it would yield identical estimates of the maximum willingness to pay for the services of the radon information agent.* Thus, our specification simplifies the issues associated with selecting a welfare measure and should be regarded as a convenient approximation.

---

*If it is interpreted as a partial equilibrium inverse demand function, then the homogeneity conditions typically imposed on an indirect utility function would not be used. Of course, the interpretation of the benefit estimates would also be different in this case.

The maximum willingness to pay, c^*, can be found by solving the expected value of Equation (5.1) for c. This is the amount of fee for the diagnostician that would equate the expected utilities in the purchase/no purchase states. It is given as

$$c^* = \frac{(a_p - a_R) + (b_p - b_R)y + (d_p - d_R)Z}{b_p} \qquad (5.3)$$

This can be expected to exceed the stated prices proposed to homeowners purchasing the service because this condition defines our estimates (see Equation (5.2)). This implies that the willingness to pay of nonpurchasers was less, on average, than the offer prices. To illustrate this point, we have reported c^* for both purchasers and nonpurchasers.

5.3 WILLINGNESS TO PAY FOR RADON INFORMATION

To estimate the model we used data from both the baseline and followup surveys of the monitored households. Our empirical model is summarized in Equation (5.4)

$$\tau_i = f\ (\text{INCOME}_i,\ \text{PRICE}_i,\ \text{RADON}_i,\ Z_i,\ \text{BROCHURE}_i) + \epsilon_i \qquad (5.4)$$

where

τ_i = an indicator variable taking on the value of one when the i^{th} respondent states he will purchase the service and zero otherwise

ϵ_i = the i^{th} radom error which is interpreted as the difference in state-specific errors (see Equation (5.2)).

This model implies that income, the proposed cost of the service (PRICE), and the measured level of radon (RADON) would be potential determinants of a household's decision. The vector Z_i includes the various socioeconomic, information, and attitudinal variables that might influence the homeowner's choice. The model also includes variables to reflect the potential effects of the type of information (BROCHURE) each household received to help them interpret their findings.

Economic theory does not provide clearcut guidance on which household characteristics or attitudes should be important in this purchase intention decision, but it does provide some general evaluation guidelines for variables such as prices and incomes. Considering a wide array of models allows us to gauge the sensitivity of our results to alternative household characteristics or attitudes. Our results generally are not sensitive to the specification chosen, and the estimates of homeowners' willingness to pay for the services of a radon diagnostician are quite robust. Table 5-1 defines the variables considered in this part of the analysis, listing the names used in subsequent tables.

TABLE 5-1. DESCRIPTION OF SOCIOECONOMIC, ATTITUDINAL, AND TECHNICAL VARIABLES

Variable/name	Description
RADON	The 2-½ month reading for radon concentration in picocuries per liter. An average value is used for those households with multiple short-term monitors.
PRICE	Proposed one-time cost of the services of the radon information agent; values were selected from $25, $50, $100, $150, $250, $400.
INCOME	Household income before taxes.
AGE	Age of respondent.
EDUCATION	Years of education completed by respondent.
NEED HELP	A qualitative variable (0,1) for respondents who indicated on the baseline survey that they did not know which government agency to turn to for help and additional information on radon (=1 if they do not know).
DOCTOR	Attitudinal variable (0,1) from the baseline survey = 1 if a respondent indicated that the statement "you always ask your physician a lot of questions or regularly read articles about health" described himself very or fairly well.
WAIT	Attitudinal variable (0,1) from the baseline survey = 1 if statement: "you usually wait until you have a lot of information before you decide to buy something new like an appliance" described himself very or fairly well.
MATH	Attitudinal variable (0,1) from the baseline survey = 1 if statement: "you are used to working with numbers or math because of your job or some other interests" described himself very or fairly well.
EXPERT	Attitudinal variable from the baseline survey = 1 if statement: "you often question information from experts or other authorities" described himself very or fairly well.
HEAR	Qualitative variable (0,1) from baseline survey = 1 if respondent had heard or read about radon in last 3 months.
TIME READING	The number of minutes the respondent reported reading the materials explaining how to interpret the radon readings (in the followup survey).
UNDERSTAND	Qualitative variable (0,1) from followup survey = 1 if the individual correctly located his reading on the risk charts provided in the brochures designed by the project or in the EPA *Citizen's Guide*.
COQUANT	Qualitative variable (0,1) = 1 if respondent received the brochure with command and quantitative design features.
COQUAL	Qualitative variable (0,1) = 1 if respondent received the brochure with command and qualitative design features.
CAQUANT	Qualitative variable (0,1) = 1 if respondent received the brochure with cajole and quantitative design features.
CAQUAL	Qualitative variable (0,1) = 1 if respondent received the brochure with cajole and qualitative design features.
EPA	Qualitative variable (0,1) = 1 if respondent received the EPA *Citizen's Guide*.
UNDLIFRISK	Qualitative variable (0,1) = 1 if respondent strongly agreed or agreed that the use of radon risk as a lifetime risk made it easier to understand personal radon risks.
UNDLIFMITIG	Qualitative variable (0,1) = 1 if respondent strongly agreed or agreed that the use of radon risk as a lifetime risk made it easier to decide on mitigation to reduce radon levels in the home.

Our empirical estimates are derived from a probit estimator that is well suited for analyzing discrete choice questions. Table 5-2 reports the results for five models, which differ according to variables used to explain homeowners' intended purchase decisions for the radon diagnostician. We evaluated all of the variables shown in Table 5-1, and the models reported in Table 5-2 are a representative sample of these results.

Model 1 is a "barebones" model that includes only the basic economic variables--the stated price for the diagnostician's services and the household's family income--and the level of radon measured in the home. The price and income variables are clearly statistically significant determinants of the stated purchase decisions. Both have the expected effects on the likelihood of a homeowner purchasing the diagnostician's services--at higher prices homeowners are less likely to purchase the service and homeowners with higher family incomes are more likely to purchase the service than those with lower incomes. Note also that the coefficient for the price variable does not change across the various model specifications, indicating a stable relationship. The coefficient for income changes somewhat in some specifications, suggesting that the income variable is reflecting the influences of other closely related socioeconomic variables (e.g., education).

In the barebones model, the level of radon in the dwelling does not significantly affect the likelihood of a homeowner purchasing the services. Homeowners with high radon levels are no more likely to purchase the services than those with low levels. Model 3 uses qualitative variables to measure the differential effect of each type of information treatment relative to the omitted type--the fact sheet. None of the estimated parameters for the information treatments is statistically significant in this simple model. However, including other attitudes, knowledge, and measures of the difficulty in reading the materials begins to lead to a clearer pattern.

By interacting the qualitative variables for the information brochures with the measured radon level, Model 5 shows that homeowners receiving the alternative information treatments are less likely to purchase the diagnostician's services than those in the fact sheet group who have the same radon level. Even more important, the positive and significant coefficient for the variable, RADON, implies that homeowners in the fact sheet group with higher radon levels are more likely to purchase the services, even though these higher levels all are less than 1 picocurie per liter.

This conclusion follows from examining the joint effects of the radon reading and information brochure. For example, an individual receiving the fact sheet exhibits an increase of .2884 in the index variable, τ, that is associated with his likelihood of purchasing the services for each picocurie of radon measured in his home. In contrast, had that individual received any of the brochures, the change in the index would be negligible (and by implica-

TABLE 5-2. PROBIT ESTIMATES FOR DECISION TO PURCHASE SERVICES OF RADON DIAGNOSTICIAN[a]

Independent variables[b]	Models				
	1	2	3[c]	4	5
INTERCEPT	.0565 (0.670)	.4836 (3.134)	.4716 (3.001)	.2303 (1.358)	.1376 (0.794)
PRICE	−.0023 (−9.083)	−.0023 (−9.130)	−.0023 (−9.146)	−.0023 (−9.087)	−.0023 (−9.044)
INCOME	$.54 \times 10^{-5}$ (2.729)	$.37 \times 10^{-5}$ (1.778)	$.43 \times 10^{-5}$ (2.090)	$.37 \times 10^{-5}$ (1.793)	$.40 \times 10^{-5}$ (1.904)
RADON	.0085 (0.756)	.0092 (0.813)	.0132 (1.126)	.0187 (1.340)	.2884 (2.290)
AGE	—	−.0067 (−2.849)	−.0067 (−2.851)	−.0074 (−3.128)	−.0072 (−3.052)
RADON * COQUANT	—	—	−.0883 (−0.836)	—	−.2776 (−2.200)
RADON * COQUAL	—	—	−.1500 (−1.378)	—	−.2808 (−2.231)
RADON * CAQUANT	—	—	−.1497 (−1.432)	—	−.2611 (−2.071)
RADON * CAQUAL	—	—	−.0926 (−0.882)	—	−.2231 (−1.781)
RADON * EPA	—	—	−.0049 (−0.045)	—	−.2859 (−2.266)
NEED HELP	— —	−.1401 (−2.113)	—	−.1160 (−1.723)	−.1131 (−1.675)
DOCTOR	—	—	—	.2523 (3.328)	.2497 (3.288)
HEAR	— —	— —	— —	.1001 (1.515)	.0992 (1.495)
TIME READING	—	—	—	.0018 (1.176)	.0029 (1.806)
UNDERSTAND * RADON	—	—	—	−.0366 (−1.737)	−.0276 (−1.254)
n	1,571	1,571	1,571	1,571	1,571
Log (L)	−1,034	−1,028	−1,029	−1,019	−1,015
χ^2	92.98	105.44	104.58	123.23	131.05

[a] Numbers in parentheses below the estimated coefficients are the ratios of these coefficients to the estimates of their asymptotic standard errors.

[b] n designates sample size, log (L) the value of the log-likelihood function at the calculated maximum, and χ^2 the chi square statistic for the null hypothesis that none of the independent variables affected the choice.

[c] The coefficients for the information treatments dummy variables in this model are not interacted with the radon measurements.

tion his probability of purchase) for increases in radon reading.* Any one of the brochures offsets the effects of the higher radon levels. This finding is consistent with those in Chapter 4, showing that homeowners receiving the fact sheet remained concerned about the level of radon in their homes. These homeowners want to find out more about radon, compared with their counterparts who received information brochures.

The findings about attitudinal and socioeconomic influences in Model 4 are similar to those for the risk perception models in Chapter 4. For example, homeowners who regularly ask their doctors a lot of questions (i.e., DOCTOR=1) are more likely to express a purchase intention. Homeowners who spent more time reading their brochures (TIME READING) are more likely to want the diagnostician's services. As noted earlier, this variable could be serving as a proxy measure of the homeowner's difficulty in interpreting his radon information. The estimated negative effect of radon readings for those who apparently understand how to interpret them, while only significant at about the 10-percent level, reinforces this interpretation. This effect is captured in the model as the product of the radon measurement (RADON) and the qualitative variable (UNDERSTAND) that describes the ability of respondents who received the radon brochures to use them correctly. That is, they could find the general location of their radon reading on a risk chart and then recall it during the followup interview. The negative coefficient for this variable in Model 4 indicates that homeowners who used the information in the radon brochures more effectively are less likely to want the additional assistance from a diagnostician. Most of the results for socioeconomic and attitudinal variables are upheld with the most detailed model, although in some cases, notably the UNDERSTAND variable, they do not remain significant determinants of the purchase decision.

The results show that older respondents are less likely to want the services of a radon diagnostician, even when differences in income, education, and other characteristics are considered (results for these models are not reported in the table but the conclusion holds). This suggests another dimension to the Chapter 4 findings that older respondents had difficulty with risk information. Our focus group experiences and other studies suggest several possible explanations for understanding these differences--older people have a greater tendency toward cognitive dissonance and are more likely to be affected by the availability bias. (See Desvousges et al. [1984], Desvousges and Cox [1986], Desvousges and Kollander [1986], and Slovic, Fischhoff, and Lichtenstein [1985].) It is also possible that older respondents are less likely to purchase these services on rational grounds. When considering their life expectancy, the long latency nature of the health effects associated with radon, and the costs of the services in relation to their means, a decision not to purchase the services may be consistent with the expected benefits relative to the expected costs. Because this is a direct implication of the estimates, we consider below how the estimated willingness to pay varies across alternative age groups. While we cannot isolate which reason accounts for our findings, they do seem to suggest that a diagnostician may not be the answer for delivering risk and mitigation information to older people because they were less likely to want their services.

---

*These marginal effects are not the changes in the probabilities of purchase. These partial derivatives scale the relevant marginal effect on the index by the value of the normal density function evaluated at the index value corresponding to the values for the relevant independent variables. Nonetheless, if this index variable is essentially zero, the marginal effect on the probability will also be small.

A somewhat surprising finding arises with the variable NEED HELP that isolates respondents who indicated in the baseline interviews that they did not know which government agency to turn to for more information. Our results suggest that they are less likely to state purchase intentions for the radon diagnostician. Although we expected them, on average, to want more radon information, the radon diagnostician does not seem to be the vehicle for delivering that information. Of course, it is also possible that the reason they did not know where to turn is because they did not care enough about the problem to find out.

As discussed earlier, the probit results can be used to estimate the maximum homeowners would pay for the services of the radon diagnostician. This was estimated separately for those stating that they would purchase the service, shown in Table 5-3, and for those who indicated they would not (Table 5-4). The homeowners had to have reported complete information on the variables included in Models 1 and 5 (from Table 5-2). The tables group the willingness-to-pay (WTP) estimates by design point and include a selected set of statistics to profile the individuals in each group.

Comparing across the tables, we find that purchasers have a higher willingness to pay for a diagnostician's services than nonpurchasers. The differences are more pronounced for the more detailed model (Equation (5)) that accounts for a wider array of individual characteristics. This indicates that factors other than those in the model may influence the decision to purchase. There are some suggestive differences in these other variables. Mean income levels seem to be higher for the purchasers than nonpurchasers. This group is also more likely to state they would like more risk and more mitigation information than the nonpurchasers. The average radon readings for purchasers in seven of the ten information design points seem to be higher than those of nonpurchasers. These differences seem most pronounced for the groups with readings of 1 picocurie or more.*

Tables 5-5 and 5-6 regroup the respondents by age classes and provide a similar set of information on purchasers and nonpurchasers. Now, we find a dramatic illustration of the effects of age that have been apparent in all of the analyses. Within each group--purchasers and nonpurchasers--the average willingness to pay for the services of a radon diagnostician is within the earlier ranges until we consider those 65 or older. In estimates based on Model 5, the willingness to pay for purchasers in the 45-to-54 age group averaged $118, while nonpurchasers in this age cohort were willing to pay only

---

*These judgments are not based on statistical tests. Sample t-tests of means are not relevant here because a stochastic behavioral process has led to the sample definitions in each case.

TABLE 5-3. WILLINGNESS-TO-PAY ESTIMATES FOR RADON INFORMATION AGENT: MEANS BY DESIGN POINT FOR PURCHASERS

Design point			WTP for radon agent[b]							
Number	Description	n[a]	(EQ1)	(EQ5)	Mean radon reading	Mean income	Need help (%)	More risk information desired (%)	More mitigation information desired (%)	Heard about radon (%)
0	Reading below 1 picocurie and information fact sheet	209	106.80	151.97	0.57	34,127	39	80	82	55
1	Reading below 1 picocurie and command/quantitative	42	108.96	100.21	0.60	35,000	36	67	71	57
2	Reading below 1 picocurie and cajole/quantitative	39	97.50	96.51	0.60	30,128	31	74	82	56
3	Reading below 1 picocurie and cajole/qualitative	35	108.20	123.19	0.49	34,857	37	77	83	51
4	Reading below 1 picocurie and command/qualitative	34	114.27	100.70	0.59	37,279	53	77	82	56
5	Reading below 1 picocurie and EPA *Citizen's Guide*	44	96.88	75.83	0.55	29,943	39	77	84	57
6	Reading 1 picocurie or more and command/quantitative	60	110.10	91.84	3.21	31,375	32	70	75	52
7	Reading 1 picocurie or more and cajole/quantitative	63	119.48	138.69	3.22	35,357	41	73	78	59
8	Reading 1 picocurie or more and cajole/qualitative	67	105.17	169.14	3.37	29,029	37	64	63	45
9	Reading 1 picocurie or more and command/qualitative	59	118.88	115.36	3.23	35,085	46	71	68	49
10	Reading 1 picocurie or more and EPA *Citizen's Guide*	55	107.93	106.51	2.69	31,273	35	71	76	56

[a] n refers to the sample size used in calculating these means; we have included only those who intended to purchase and had no missing values for the independent variables in the relevant models.

[b] Equation numbers refer to the models reported in Table 5-2.

TABLE 5-4. WILLINGNESS-TO-PAY ESTIMATES FOR RADON INFORMATION AGENT: MEANS BY DESIGN POINT FOR NONPURCHASERS

Design point			WTP for radon agent[b]							
Number	Description	n[a]	(EQ1)	(EQ5)	Mean radon reading	Mean income	Need help (%)	More risk information desired (%)	More mitigation information desired (%)	Heard about radon (%)
0	Reading below 1 picocurie and information fact sheet	234	97.75	124.73	0.53	30,341	42	70	64	47
1	Reading below 1 picocurie and command/ quantitative	48	95.02	45.46	0.53	29,166	42	50	58	48
2	Reading below 1 picocurie and cajole/ quantitative	56	104.45	90.12	0.57	33,125	39	64	66	54
3	Reading below 1 picocurie and cajole/ qualitative	50	109.59	94.22	0.55	35,350	50	58	56	52
4	Reading below 1 picocurie and command/ qualitative	45	97.88	62.97	0.50	30,444	49	53	60	44
5	Reading below 1 picocurie and EPA *Citizen's Guide*	44	95.84	57.69	0.55	29,488	52	55	64	53
6	Reading 1 picocurie or more and command/quantitative	83	113.96	78.87	2.89	33,524	47	39	41	45
7	Reading 1 picocurie or more and cajole/quantitative	83	100.35	82.01	2.50	28,343	36	43	41	45
8	Reading 1 picocurie or more and cajole/qualitative	77	102.85	115.60	2.15	29,967	51	55	51	44
9	Reading 1 picocurie or more and command/qualitative	78	107.51	66.53	3.57	29,711	50	50	50	56
10	Reading 1 picocurie or more and EPA *Citizen's Guide*	67	115.32	93.87	2.94	34,029	45	48	52	49

[a] n refers to the sample size used in calculating these means; we have included only those who intended to purchase and had no missing values for the independent variables in the relevant models.

[b] Equation numbers refer to the models reported in Table 5-2.

TABLE 5-5. WILLINGNESS-TO-PAY ESTIMATES FOR RADON INFORMATION AGENT: MEANS BY AGE CLASS FOR PURCHASERS

Age (A) class	n[a]	WTP for radon agent[b]		Mean radon reading	Mean income	Need help (%)	More risk information desired (%)	More mitigation information desired (%)	Heard about radon (%)
		(EQ1)	(EQ5)						
18 ≤ A < 30	74	100.98	177.76	1.51	30,168	47	80	77	53
30 ≤ A < 45	294	116.61	152.66	1.67	36,581	39	61	63	59
45 ≤ A < 55	139	114.56	118.10	1.70	35,647	34	73	81	55
55 ≤ A < 65	133	101.16	85.08	1.74	29,887	36	74	76	47
65 ≤ A	63	80.28	35.40	1.84	20,833	41	60	64	51

[a] n refers to the sample size used in calculating these means; we have included only those who intended to purchase and had no missing values for the independent variables in the relevant models.

[b] Equation numbers refer to the models reported in Table 5-2.

TABLE 5-6. WILLINGNESS-TO-PAY ESTIMATES FOR RADON INFORMATION AGENT: MEANS BY AGE CLASS FOR NONPURCHASERS

Age (A) class	n[a]	WTP for radon agent[b]		Mean radon reading	Mean income	Need help (%)	More risk information desired (%)	More mitigation information desired (%)	Heard about radon (%)
		(EQ1)	(EQ5)						
18 ≤ A < 30	87	98.91	147.52	1.26	29,684	45	74	60	45
30 ≤ A < 45	330	112.60	134.40	1.45	35,212	42	63	62	53
45 ≤ A < 55	152	112.19	85.03	1.54	34,901	42	50	49	46
55 ≤ A < 65	151	95.58	58.38	1.59	27,748	44	48	54	48
65 ≤ A	145	82.45	9.01	1.94	21,603	55	42	45	42

[a] n refers to the sample size used in calculating these means; we have included only those who intended to purchase and had no missing values for the independent variables in the relevant models.

[b] Equation numbers refer to the models reported in Table 5-2.

$85 on average. In contrast, the average willingness to pay for purchasers in the highest age group is $35 and only $9 for nonpurchasers.

All else equal, the model would imply (i.e., the negative coefficient for age) that older respondents would be expected to pay less. However, this rather striking reduction, especially among nonpurchasers, indicates that the combination of older respondents' characteristics together with their ages makes them less likely to be willing to purchase these services for radon information. Comparing the calculations from Equation (1) (with no socioeconomic and attitudinal variables) with those from Equation (5) illustrates this effect.

Given the latency period of the health effect and the life expectancy for members of this group, this behavior could be consistent with rational behavior on their part. However, this conclusion is not obvious. It is reasonable to expect that knowledge of high radon levels in homes will affect the market values of their homes. Thus, even if the direct personal benefits from mitigation are modest, given some bequest motives, it could still be rational for older households to take mitigating actions. Thus, identifying the source of these discrepancies could be quite important. If it is a rational response of older respondents and not a failure of the information materials, it could represent clear evidence of rational decisionmaking for activities involving risk.

Turning to the specific effects of the information brochures, the results for the homeowners expressing the intention to purchase who had received the fact sheet are the most striking. With mean radon readings of slightly more than one-half a picocurie per liter, the average value of the willingness to pay for the 209 homeowners in this group was $152. These amounts are comparable to homeowners receiving the radon brochures who had an average radon reading of at least 2.69, with the averages for most above 3 picocuries per liter. The fact sheet group had the second highest average WTP amounts among all the design components, despite having very low radon readings. The homeowners receiving the qualitative/cajole brochures (Designs 3 and 8) had the highest willingness to pay among all the groups. In this group, the homeowners below 1 picocurie were willing to pay between $108 and $123, and those with readings above 1 picocurie per liter were willing to pay between $105 and $169.

The same tendency for increased demands for information among those receiving only the fact sheet (Design Point 0) was apparent with the nonpurchasers. The average of their willingness to pay exceeded the means estimated for all respondents with readings of 1 picocurie or more.

Overall, the empirical results for the radon diagnostician models are encouraging. The findings reinforce conclusions about risk perceptions that emerged in Chapter 4. Homeowners receiving only the fact sheet are concerned about their radon levels and this concern reveals itself in their willingness to pay for more risk information. Older homeowners may be responding rationally to their situations or they may be experiencing more difficulty processing risk information. Our findings clearly indicate that they are less likely to want the services of a radon diagnostician. Distinguishing which of these explanations fits these responses is an important area for further research.

Finally, the statistical performance of the models is quite good, with very stable estimates for the parameters and signs that are consistent with economic theory. The WTP amounts estimated with the models also are plausible and fall within a reasonably narrow range.

5.4 RADON COMMUNICATION CHANNELS

In our baseline surveys, we asked homeowners where they would be most likely to turn for more information about radon. Our objective was to assess whether people had a clearly established channel in mind for acquiring information about radon.

Figure 5-1 shows that over 40 percent of New York homeowners in the baseline survey did not know where to get more information about radon. This lack of awareness about sources for radon information was true even for homeowners in the NYSERDA monitoring study, which is sponsored by a State agency. Only 5 percent said they would turn to that agency. Those homeowners who had a communications source in mind are most likely to turn to the New York State Department of Environmental Conservation. About 20 percent of the homeowners would inquire there for more information about radon. These people would be surprised because most of the responsibility for radon in New York rests with NYSERDA and the Department of Health. Less than 10 percent of the homeowners had either of these agencies in mind as a channel for radon information. Because communication plays a major role in the overall risk management policies for radon, the lack of a clear source for information is likely to be important to the effectiveness of future information programs at the state level.

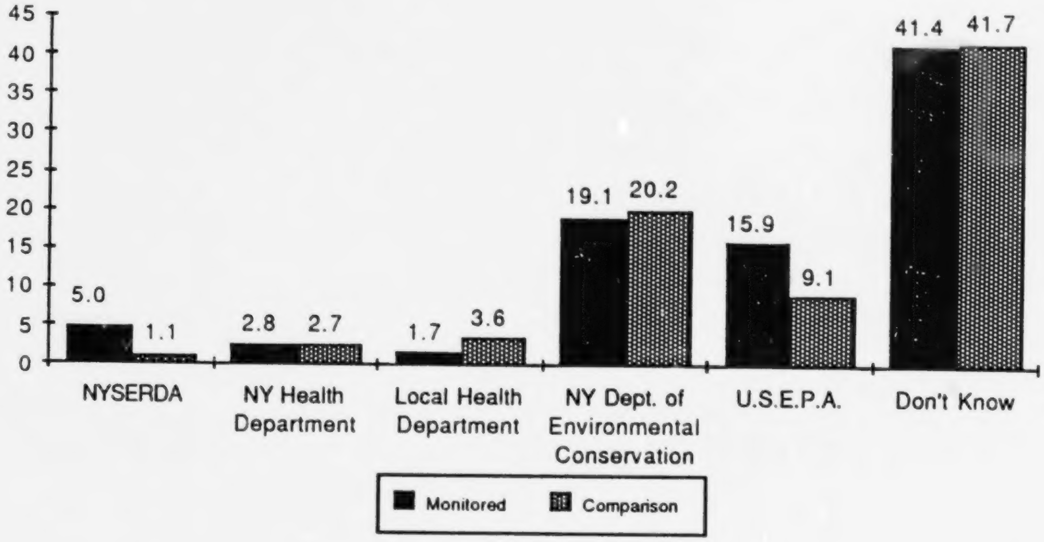


Figure 5-1. Where would New York homeowners turn for radon information?

To follow up on this communications channel issue, we asked the homeowners in the NYSERDA monitoring study whether they had acquired information about radon since the baseline survey. The top part of Figure 5-2 shows the responses for the NYSERDA homeowners who had an agency in mind in the baseline survey and those who did not. Generally, the large differences between these groups has not carried over into the followup survey. Homeowners who did not know where to turn were almost as likely (64 vs. 74%) to have acquired information between the baseline and followup interviews as their counterparts who did know where to turn. As shown in the lower part of Figure 5-2, both groups of homeowners get their information from the same mix of sources.

We also asked homeowners in the followup survey with whom they had discussed their radon readings. Figure 5-3 shows the relative frequency of responses for both the homeowners who did not know where to turn for more information and those who did. The percentages for the groups are about the same, except that about 5 percent more of the "don't know" group had discussed their readings with a family member. Almost no one in either group contacted a public official or any government agency--Federal, State, or local--to discuss their results. After having received their results and information materials, they felt no need to go outside their family, friends, or neighbors to discuss their results. This finding is especially important for agencies, such as NYSERDA, that have to carefully manage their communication resources. Homeowners did not find it necessary to seek more information from the agency.

To explore the potential market for alternative communication sources or vehicles for delivering information about radon, we asked homeowners in the NYSERDA monitoring group how likely they would be to use information from: a longer risk brochure, a longer mitigation brochure, a panel of experts at a town meeting, and a phone call from a State agency. Figure 5-4 shows the percent of respondents who would be either likely or very likely to use any of these communication channels. The top part of the figure compares the people who did not know where to turn for more information with those who did. Both groups strongly prefer printed information to the other sources for risk information, with at least 60 percent likely to use a longer risk brochure and 63 percent likely to use a longer mitigation brochure. In contrast, only 48.6 percent would be likely to use the phone call from a State Agency, and only 37.7 percent would be likely to attend a meeting that included a panel of experts. The groups expressed similar preferences, except that the "don't know" group was less likely to use the phone call.

The bottom part of Figure 5-4 illustrates the responses to the same questions but compares homeowners living in the Binghamton stratum with those in all the other strata. We are interested in the Binghamton area because its residents had the highest readings and might provide a sufficient concentration of respondents to permit organizing a town meeting or some other group-related mechanism for communicating radon risk information. The results show that 42 percent of the homeowners in the Binghamton stratum would be likely to attend a town meeting that included a panel of experts. This was about 5 percent higher than the other strata but still considerably below the support for longer information brochures. On the whole, the homeowners in the Binghamton stratum prefer about the same radon communication sources as their counterparts in other strata.

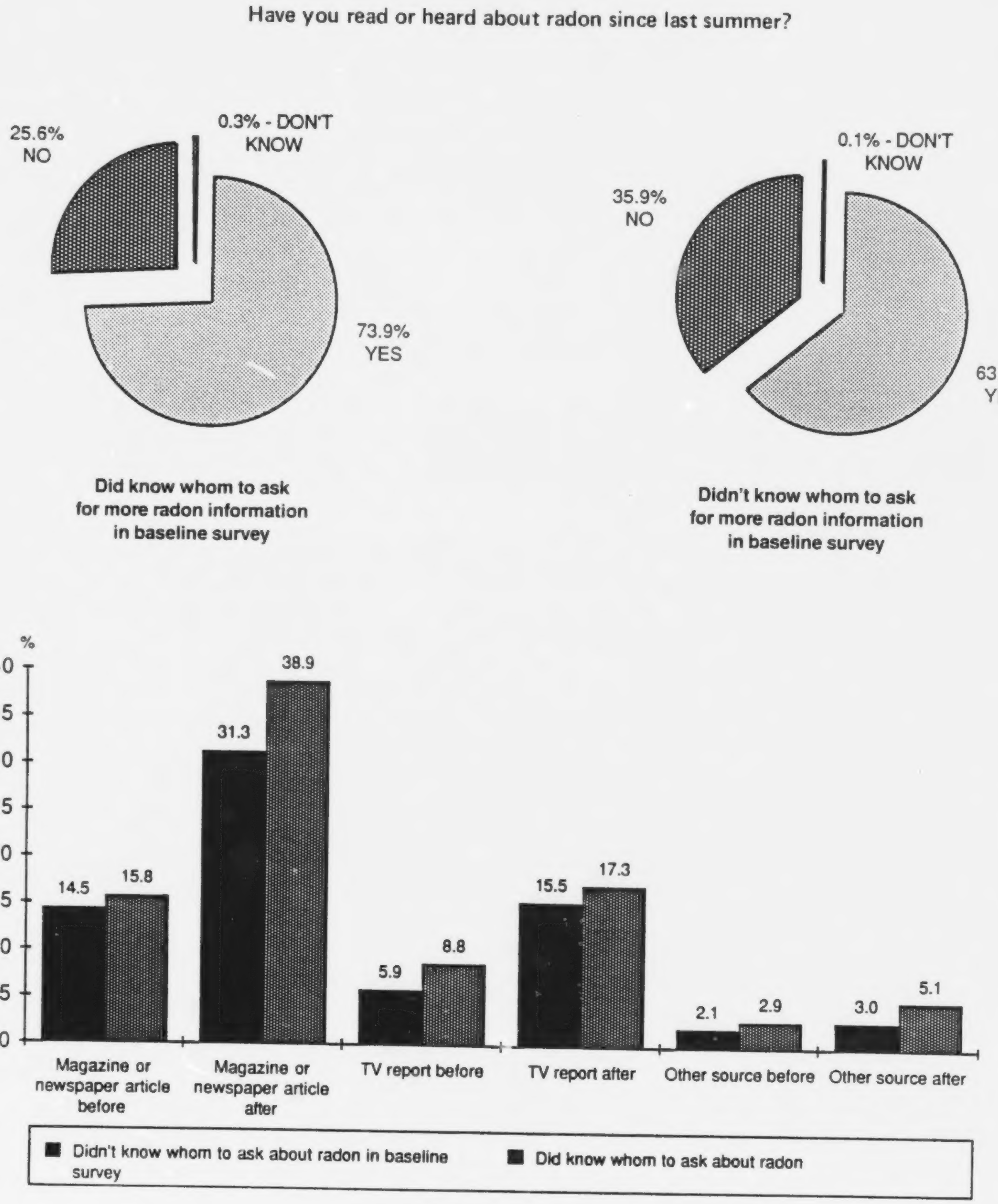


Figure 5-2. Sources of additional radon information used.

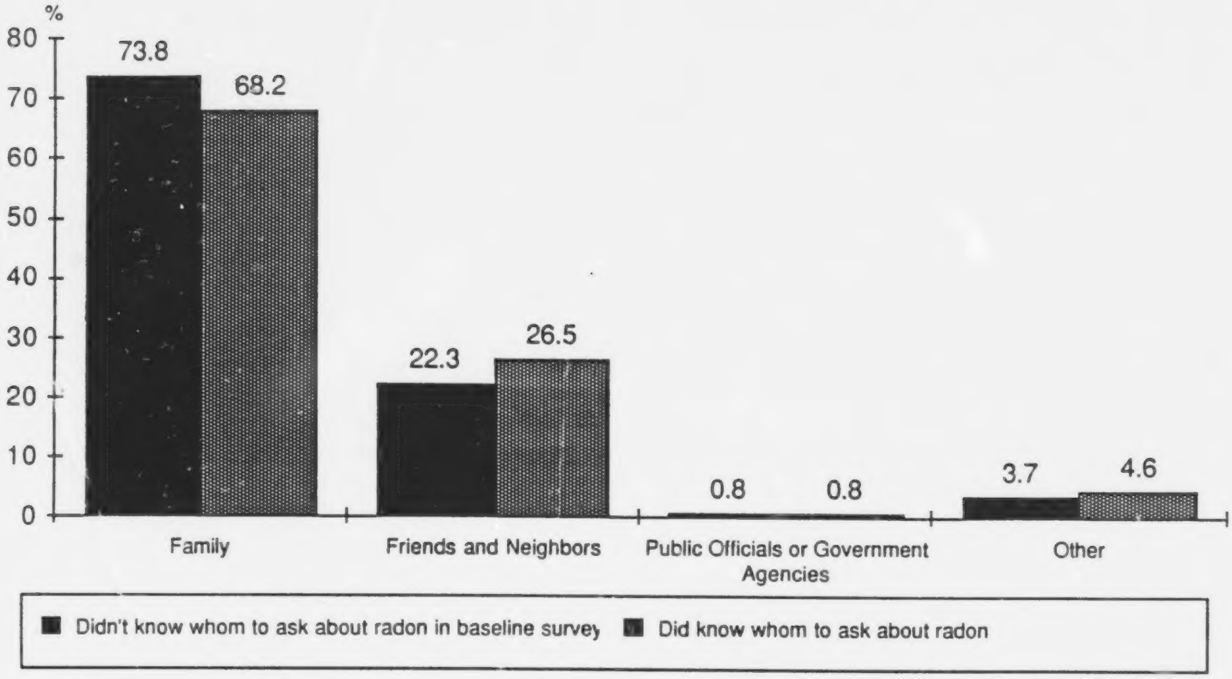
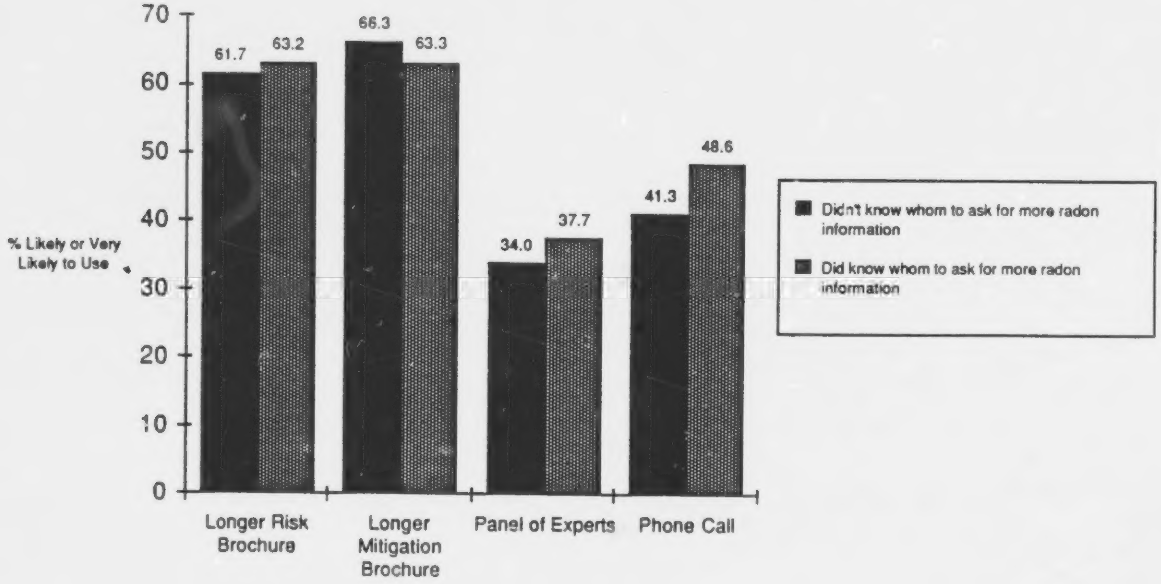


Figure 5-3. People with whom New York homeowners discussed their radon readings.



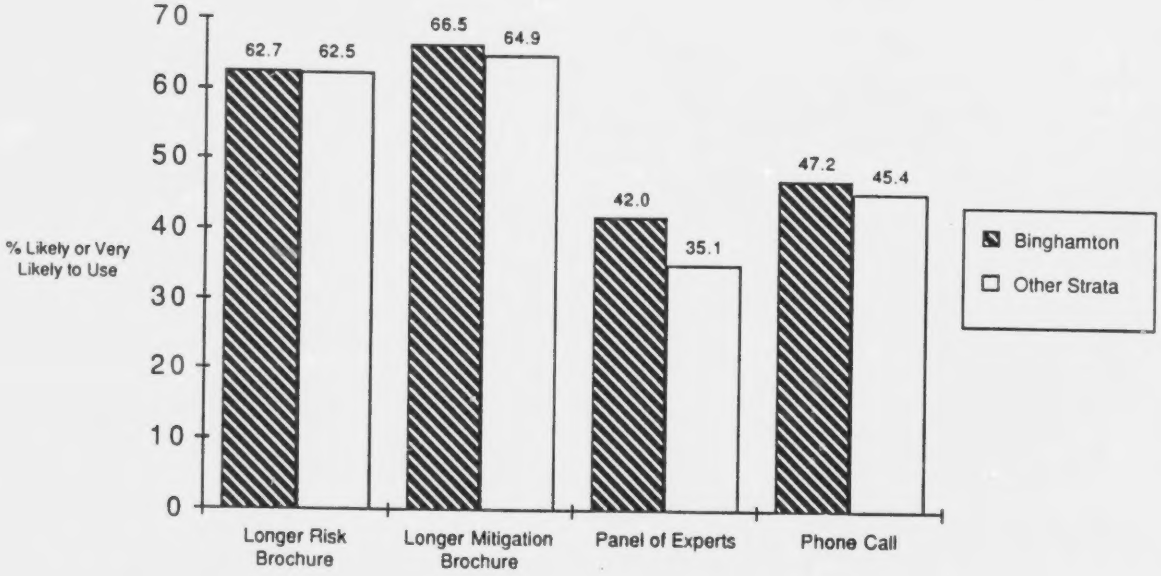


Figure 5-4. Alternative delivery vehicles for additional radon information.

Figure 5-5 shows the same information classified by the type of information the homeowners received. Once again the people who received only the fact sheet would be much more likely to use a longer brochure on radon risk or mitigation. Almost three-fourths of these homeowners would be likely to use either type of brochure. For the risk brochure, the next highest group (63 percent) were homeowners receiving the command-qualitative brochure; only 54 percent of the homeowners receiving the command-quantitative brochure were likely to want a longer risk brochure. Across all the delivery vehicles, the town meeting had the least support, even among the fact-sheet group. Figure 5-6 presents these responses grouped according to the radon level. The results are similar to those for the type of information. Homeowners with radon levels above 20 picocuries show a slight preference for a phone call from a State Agency, along with a preference for longer risk and mitigation brochures. Even for this higher risk group, however, only 54.5 percent stated they would be likely, or very likely, to use the communication channel.

We again used the probit estimator to further examine the likelihood that homeowners in the NYSERDA monitoring group would use longer brochures on either radon risks or radon mitigation. Table 5-1 describes the variables used in these models, and Table 5-7 shows the results for a longer brochure on radon risks and a longer one on reducing radon levels in the home. For these models, we assigned a "1" to homeowners who said they would very likely or likely use the longer brochure and a "0" to all the other responses (including "don't knows").

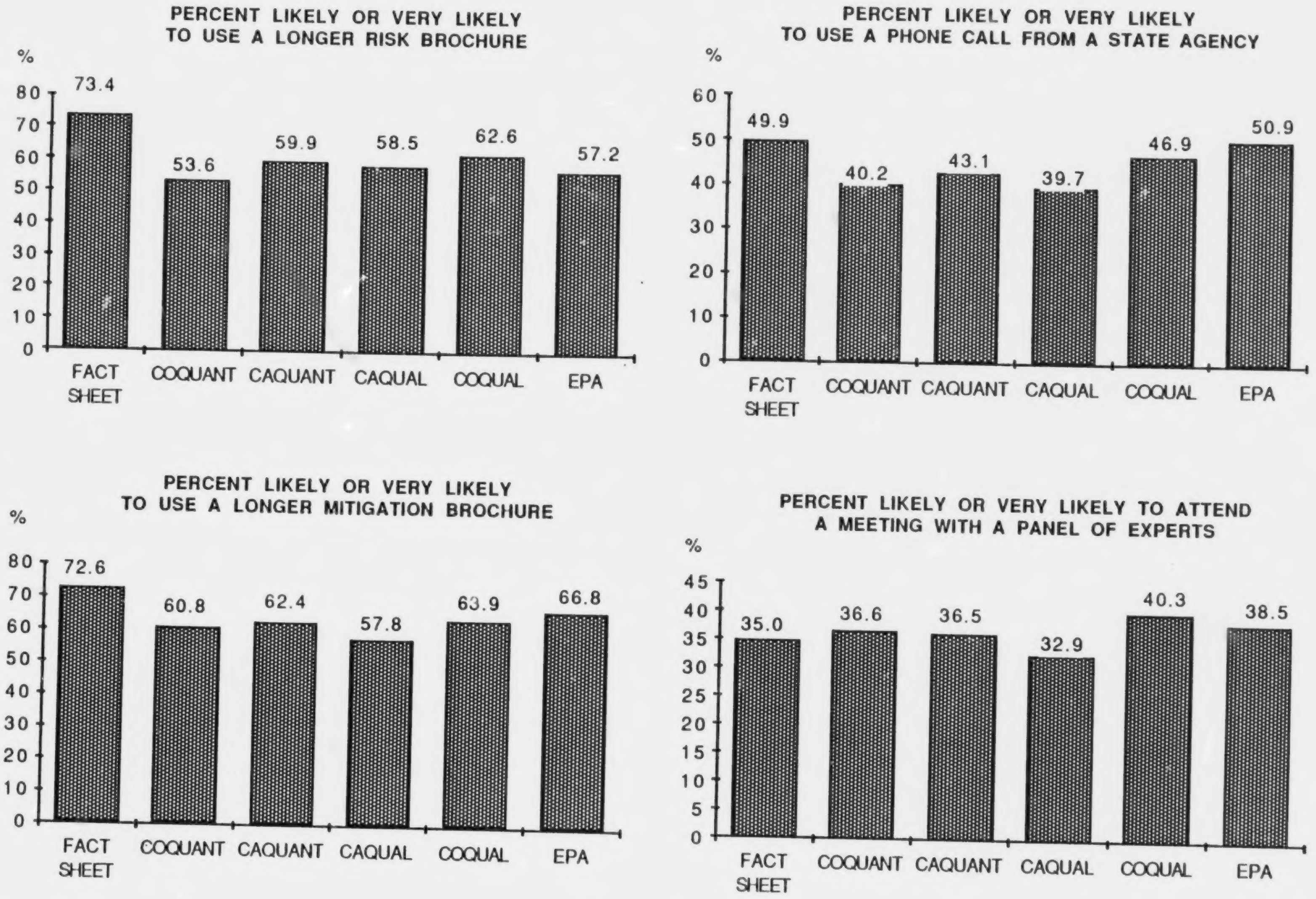
To evaluate the potential effect of the various radon brochures on the likelihood of using longer brochures, we used qualitative variables for each type of brochure. Each qualitative variable's coefficient indicates the relative effect on use in comparison with the fact sheet. The results show that the homeowners receiving any of the brochures are much less likely to use a longer risk brochure. Homeowners receiving the command/quantitative brochure are the least likely, followed by those receiving the EPA *Citizen's Guide*.* The fact-sheet group's desire for more information is consistent with the Chapter 4 results. Table 5-7 shows that these concerns carry over in their desire for more information on radon risks.

In developing the experimental radon brochures, we considered whether the brochures had enough information on risks, especially for homeowners who experienced high radon levels in the homes. The results in Table 5-7 show that there is no significant relationship between the level of radon in people's homes and their likelihood of wanting more information about radon risks.

Personal characteristics and attitudes also affected the likelihood of people wanting more information on radon risks. Table 5-7 indicates that older people were less likely to want more information about radon risks. These findings are further support for examining whether this is a rational

---

*An approximate statistical test can be performed by comparing the coefficients. The more proper test would examine covariances between variables. See Kmenta [1986]. Given the independence in assigning homeowners to a design point, these test results that ignore these covariances are unlikely to differ from those that include them.

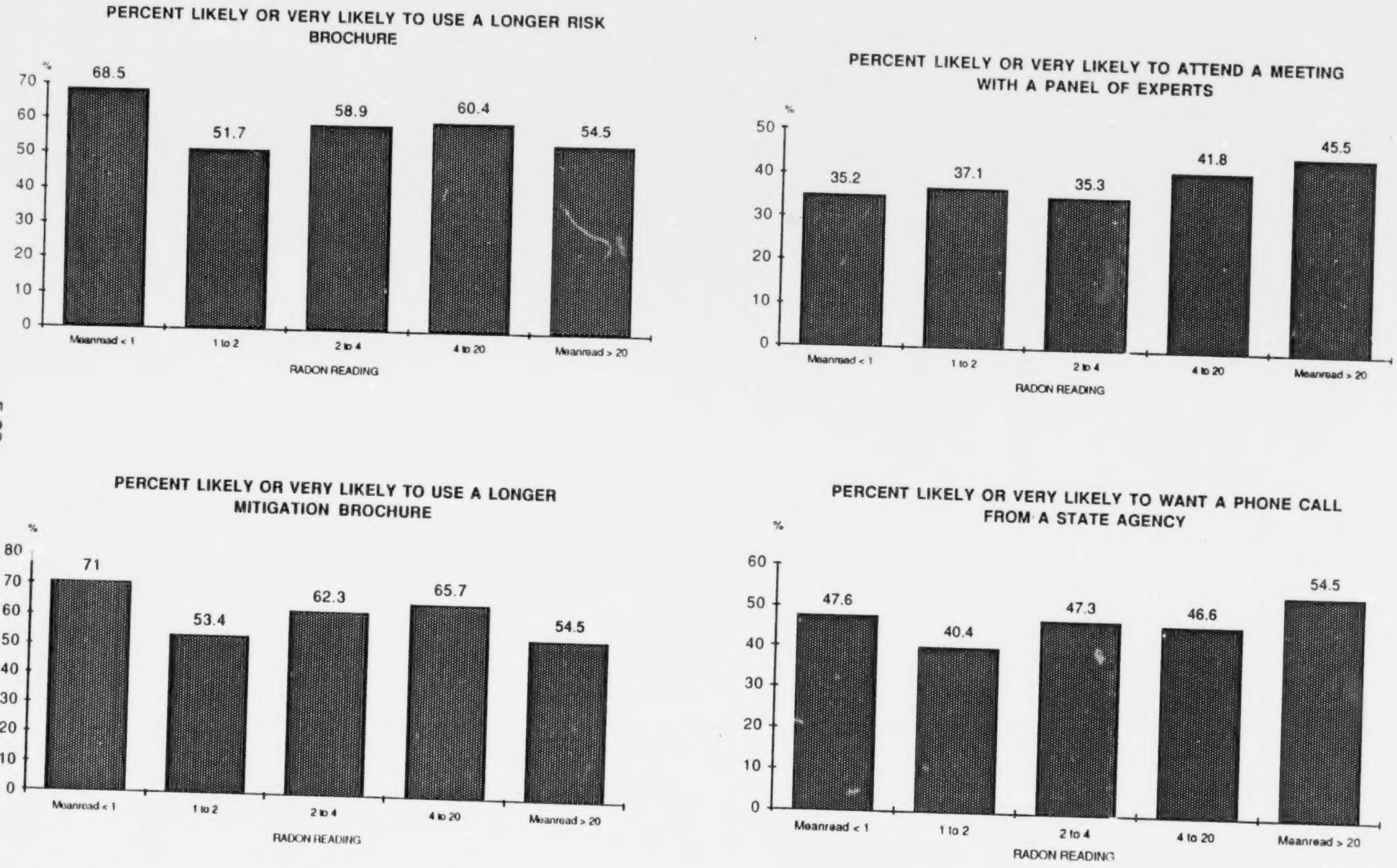

PERCENT LIKELY OR VERY LIKELY TO USE A LONGER RISK BROCHURE

PERCENT LIKELY OR VERY LIKELY TO USE A PHONE CALL FROM A STATE AGENCY

PERCENT LIKELY OR VERY LIKELY TO USE A LONGER MITIGATION BROCHURE

PERCENT LIKELY OR VERY LIKELY TO ATTEND A MEETING WITH A PANEL OF EXPERTS

Figure 5-5. Alternative delivery vehicles for additional radon information by version.



PERCENT LIKELY OR VERY LIKELY TO USE A LONGER RISK BROCHURE

PERCENT LIKELY OR VERY LIKELY TO ATTEND A MEETING WITH A PANEL OF EXPERTS

PERCENT LIKELY OR VERY LIKELY TO USE A LONGER MITIGATION BROCHURE

PERCENT LIKELY OR VERY LIKELY TO WANT A PHONE CALL FROM A STATE AGENCY

Figure 5-6. Preferences for communication channels by radon reading.

TABLE 5-7. WHO IS LIKELY TO USE LONGER BROCHURES: PROBIT RESULTS

Independent variables	Longer risk brochure	Longer mitigation brochure
INTERCEPT	1.4262 (5.994)	1.1636 (5.001)
RADON	−0.0062 (−0.561)	0.0017 (0.154)
AGE	−0.0165 (−7.216)	−0.0115 (−5.090)
EDUCATION	−0.0245 (−1.798)	−0.0229 (−1.691)
COQUANT	−0.6005 (−4.275)	−0.5010 (−3.608)
COQUAL	−0.4464 (−3.177)	−0.4746 (−3.353)
CAQUANT	−0.4657 (−3.355)	−0.4385 (−3.218)
CAQUAL	−0.4601 (−3.181)	−0.5385 (−3.827)
EPA	−0.5103 (−3.507)	−0.3402 (−2.331)
DOCTOR	0.3369 (4.638)	0.2274 (3.146)
TIME READING	0.0039 (2.337)	0.0019 (1.171)
HEAR	0.1465 (2.278)	0.0908 (1.419)
WAIT	0.0235 (0.285)	0.0715 (0.875)
UNDLIFRISK	0.0003 (0.202)	— —
UNDLIFMITIG	— —	0.1583 (1.516)
n	1,730	1,730
Log (L)	−1,064.8	−1,076.5
χ^2	120.94	63.395

response given their personal circumstances or that this relationship suggests that merely providing older people with more information will not be effective. In the latter case, a more direct program, perhaps with personal counseling or information tailored to their concerns, may be needed to enhance the effectiveness of risk communication with older people.

Homeowners who had read or heard about radon in the baseline survey are more likely to use a longer brochure on radon risks. People who spent a longer time reading the current materials also are more likely to use a longer risk brochure. This variable could be a proxy for people who had difficulty interpreting their results. The negative sign for the education variable suggests more educated people are less likely to use a longer brochure, but the relationship was not statistically significant.

The most significant attitudinal variable, whether or not someone usually asks their physician health questions (DOCTOR), shows these people are more likely to use a longer brochure on radon risks. Again, this relationship reinforces our earlier findings on the influence of personal characteristics. Overall, our results show that people who are more aware about radon, who spent a longer time reading their current brochures, and who regularly question their physicians about health are more likely to want a longer brochure on radon risks. The second column in Table 5-7 indicates similar results for the factors influencing the likelihood a respondent would use a longer mitigation brochure. The primary differences are the insignificant estimates for variables associated with having heard of radon prior to the baseline survey and with the time spent reading the materials.

5.5 CONCLUSIONS

This chapter used economic models and descriptive statistics to explore homeowners' demand for radon information. Using the data from the baseline and followup surveys, we have evaluated the likelihood that people would use various communication sources, as well as their intentions about purchasing the services of a radon diagnostician. The relative stability of the estimates for the demand for a diagnostician's services shows the potential for using carefully framed hypothetical questions to explore potential market demands.

The important findings of this chapter include:

- The willingness to pay for the services of a radon diagnostician among those stating a purchase intention, given the fee they were offered, ranged from $75 to $170, while those who were nonpurchasers at proposed fees had been willing to pay estimates ranging from $45 to $125. The probit models' estimates were remarkably stable and robust to alternative specifications.

- The probit results showed higher income homeowners more likely to intend to purchase the service with the intent to purchase declining as the offer price increased. Both the findings are consistent with economic theory.

- People who received only the fact sheet were significantly more willing to demand the services of a radon diagnostician than those receiving one of the five information brochures. They also were more likely to ask for more information on risk and on mitigation.

- None of the risk communication channels we have evaluated seems to work for older people. They were less likely to intend to purchase the services of a radon diagnostician and less likely to use additional information brochures on either radon risks or mitigation. Because older people experienced problems in evaluating their risks (see Chapter 4), it is important to determine whether these responses to the diagnostic services are a rational response, given their circumstances or a reflection of the need to find a more effective source for communicating risk information to them.

- Receiving the risk information as part of this risk communication project has helped people who did not have a clear communications source in mind before getting radon information. They showed no differences with whom they discuss radon risks or in the sources they would contact for more radon information. Homeowners also did not find it necessary to seek additional information from NYSERDA, other government agencies, or public officials. Less than 1 percent contacted these groups after receiving their information.

- Less than 1 percent of the homeowners contacted a government Agency or public official after receiving their radon readings and information materials. This implies that the NYSERDA information program effectively reduced the need for more information from governmental sources. Nevertheless, homeowners in New York are not likely to know which Agencies to turn to for more information about radon. Less than 8 percent would have turned to the right agency.

- People use informal communication channels more than formal ones to find out more about radon. When they discussed their radon results, it was more likely to be with family members, friends, relatives, and neighbors.

- Homeowners in the monitored sample favor printed brochures over other communication channels. Only homeowners with high radon levels stated a preference for a phone call from a State Agency, but even with this group the preference was slight.

Overall, the radon diagnostician may offer some promise as a vehicle for delivering radon information. Such services would not be a panacea. More targeted information, perhaps through a conventional channel (the Council on Aging or American Association of Retired Persons) may well offer the best potential for helping older citizens understand their risks from radon. Generally, printed media appear to be the main channel preferred by homeowners participating in the measurement study. This implies that our initial focus on the brochures has been well placed. As we discuss in the next chapter, EPA's broader risk communication needs--e.g., getting people to test their homes--may require more innovative approaches using multiple channels.

5.6 REFERENCES

Bishop, Richard C., and Thomas A. Heberlein, 1979, "Measuring Values of Extra Market Goods: Are Indirect Measures Biased?" *American Journal of Agricultural Economics*, Vol. 61, No. 5, December, pp. 926-30.

Cameron, Trudy Ann, and Michelle D. James, 1987, "Efficient Methods for 'Closed Ended' Contingent Valuation Surveys," *Review of Economics and Statistics*, Vol. LXIX, No. 2, May, pp. 269-76.

Desvousges, William H., and James A. Cox, 1986, "Radon Focus Groups: A Summary," Report to U.S. Environmental Protection Agency, Research Triangle Institute, Research Triangle Park, North Carolina, August.

Desvousges, William H., and Mel Kollander, 1986, *Radon Focus Groups: A Summary*, Research Triangle Institute Report to the Assistant Administrator for Policy, Planning, and Evaluation of the U.S. Environmental Protection Agency, January.

Desvousges, William H., V. Kerry Smith, Diane H. Brown, and D. Kirk Pate, 1984, *The Role of Focus Groups in Designing a Contingent Valuation Survey to Measure the Benefits of Hazardous Waste Management Regulations*, draft technical report prepared for U.S. Environmental Protection Agency, Research Triangle Institute, Research Triangle Park, North Carolina.

Feldstein, Martin, 1974, "Econometric Studies of Health Economics," in M. Intrilligator and D. Kendrick, eds., *Frontiers of Quantitative Economics*, II, Amsterdam: North Holland.

Hanemann, W. Michael, 1984, "Welfare Evaluations in Contingent Valuation Experiments with Discrete Responses," *American Journal of Agricultural Economics*, Vol. 66, No. 3, August, pp. 332-41.

Kmenta, Jan, 1986, *Elements of Econometrics*, 2nd Edition, New York: MacMillan Co.).

Ross, Stephen, 1973, "The Economic Theory of Agency: The Principal's Problem," *American Economic Review*, Proceedings, Vol. 63, May, pp. 134-39.

Shavell, Steve, 1979, "Risk Sharing and Incentives in the Principal and Agent Relationship," *Bell Journal of Economics*, Vol. 10, Spring, pp. 55-73.

Slovic, Paul, Baruch Fischhoff, and Sarah Lichtenstein, 1985, "Regulation of Risk: A Psychological Perspective" in Roger Noll, ed., *Regulatory Policy and the Social Sciences*, Berkeley, California: University of California Press.

Smith, V. Kerry, and William H. Desvousges, 1986, *Measuring Water Quality Benefits*, Boston: Kluwer-Nijhoff.

Stiglitz, Joseph, 1974, "Risk Sharing and Incentives in Sharecropping," *Review of Economic Studies*, Vol. 61, April, pp. 219-56.

CHAPTER 6

THE OVERALL EFFECTIVENESS OF THE NYSERDA RISK COMMUNICATION PROGRAM AND FUTURE RESEARCH ISSUES

6.1 INTRODUCTION

The overall evaluation of effectiveness consists of two parts. Part 1 evaluates the consistency between perceived and technical risk estimates, addressing Russell's [1986] question, "Do the right people worry and the others stop?" Part 2 considers the findings of the three previous chapters on learning, risk perception formation, and the demand for information to address the question, "Which brochure was best?"

This effectiveness evaluation is based on a study that is unique as a social science experiment involving households' responses to risk. At the same time, its activities are part of an actual risk communication program in which NYSERDA (and EPA to the extent the materials cite EPA risk estimates and action guidelines) is delivering information to 2,300 homeowners about their radon exposures and what these exposures mean. The potential public health implications of this second function of the research led us to evaluate the program's effectiveness on the basis of data available now. From the perspective of a research project, it would be better to wait until all the data are available. However, interim results could signal shortcomings in the risk communication aspects of NYSERDA's study. Such shortcomings could be addressed before sending the annual radon readings to homeowners, enabling NYSERDA to minimize potential misunderstanding of the readings and their interpretations.

Our evaluation of effectiveness is therefore a "mid-course" appraisal. There are two reasons for this characterization. First, it is based only on what households learned about radon and its risks and on how households formed risk perceptions. We do not know yet what those at high risks will do about them. Nor do we know whether those with low risks will worry and undertake mitigating expenditures that are unwarranted. Second, the risk communication program is not finished. The homeowners know they are to receive more information. The brochures encouraged all but those with very high radon readings to postpone expensive mitigation decisions until they received their additional readings. A final evaluation can be made only after the process of delivering the information is completed. The mid-course appraisal is a suggestive evaluation of some aspects of the performance of this information program, but not conclusive.

Preceding page blank

6.2 CONSISTENCY BETWEEN PERCEIVED AND TECHNICAL RISK ESTIMATES

Our first evaluation of the overall effectiveness of the NYSERDA risk communication program considers whether the program achieved consistency between homeowners' perceived risks and their actual risks from radon. This evaluation uses the reported risk perceptions information and technical estimates of the actual risks.

The first step in the evaluation is to develop estimates of the actual risks each household is experiencing from the radon in their homes. (Hereafter, we use the term technical risk estimates.) Ideally, such estimates would be based on a detailed dose-response model that includes the level of radon exposure as well as other activities (e.g., smoking) that might influence risks.* Such studies are only now getting underway. Studies of other risks have used averages of experts' judgments or the average frequency that certain events occur (e.g., deaths from automobile accidents or plane crashes). Slovic, Fischhoff, and Lichtenstein [1980] and Fischhoff et al. [1978] have used the latter route in their comparisons of technical risk estimates with average risk perceptions.

In this study, we have used the increment of lifetime risk estimates developed by the EPA Office of Radiation Progams that vary by the level of exposure to radon and the length of exposure period. Equation (6.1) uses these data to estimate the relationship implied by these estimates and the level and duration of exposure. Using the log of these variables provides a tight fit of the model to the data, as evidenced by the high R^2. The high t-ratios in parentheses below the estimated parameters provide a gauge of how well this model performs as a statistical summary of the EPA model.

$$\begin{aligned} \log(\text{TRISK}) = \underset{(-112.111)}{-8.739} + \underset{(49.309)}{.918}\log(\text{years}) + \underset{(46.923)}{.958}\log(\text{RADON}) \end{aligned} \qquad (6.1)$$

$R^2 = .989$

$s = .210.$

We used this model to estimate each respondent's increment to his lifetime risk of premature death from lung cancer caused by radon. We estimated two risk measures that differ by the assumed duration of the exposure. The first measure, designated the "current risk estimate," uses the number of years the household reported they had lived in their home to approximate the duration of exposure. It reflects only the time they have been exposed as of the date of their interviews. It does not reflect their plans to stay in the current home. The second, designated the "potential risk estimate," adds an estimate of anticipated future exposure to the time used for the current risk estimate. This time estimate corresponds to the remaining life expectancy for each individual. To calculate remaining life expectancy, we assigned each respondent a life expectancy based on sex and current age. Thus, the potential risk estimate assumes they would spend the rest of their lives in their current homes (or one leading to similar radon exposure).

---

*This would require a complete diary of how much time each respondent spent in each section of the house, along with radon readings for each of these areas. We also would need to allow for potentially synergistic relationships among an individual's other activities.

Our technical risk estimates are preliminary in two respects. First, they assume the households correspond to the behavioral assumptions inherent in the EPA risk assessment model. Second, the estimates do not reflect actual exposure patterns for the household. The NYSERDA measurement study collected detailed data on variables that could affect exposure, but these were not available in time for this mid-course appraisal.

6.2.1 Comparison 1: Perceived Risk Messages and Technical Risks

Our first comparison with the technical risk estimates views risk perception as a behavioral process. Individuals received the risk information (brochures and radon readings) and used it to update their prior assessments of their risks. If the information policy's primary goal is to communicate information on the risk from radon exposure, then the relevant basis for measuring perceptions is the perceived risk message obtained from the information materials. We can infer this perception from the relationship between people's responses to the questions on their personal risks in the baseline and followup surveys. This approach asks what perceived risk message is consistent with the relationship between people's prior and posterior risk assessments. These can be estimated with the Bayesian model described in Equation (4.1) in Chapter 4. The model combines people's characteristics and the features of the information they received with estimates of the parameters of the Bayesian model to calculate the perceived risk message or what we referred to as the implicit sample risk in Chapter 4.

Comparing these estimates with the technical risk estimates is a statistical exercise that considers how well the information materials communicated the risks. It is not a hypothesis test. Both the dependent variable (i.e., sample risk estimate) and the independent variable (technical risk estimate) in these models were constructed from these individuals' characteristics, radon readings, and other variables. We would expect there to be some relationship between these risk messages simply because there are variables in common (e.g., age) in the determinants of each of these estimates. This approach compares the implications of two sets of maintained hypotheses to evaluate what risk message people received from the information materials and compares it with the technical risk estimate that would be attributed to them. Table 6-1 reports the ordinary least-squares (OLS) estimates of this relationship. The sample is confined to individuals who reported prior and posterior risk assessments for their personal risks from radon exposure. The perceived risk message is estimated based on Equation (3) in Table 4-7. They ranged from .050 to .749, while the technical risk estimates ranged from 0 to .073 using the current risk definition and 0 to .169 with the potential risk definition.

TABLE 6-1. SAMPLE vs. TECHNICAL RISKS FROM RADON[a]

Independent variables	Models[b] (1)	(2)
INTERCEPT	.2192 (111.558)	.2075 (110.964)
Current technical risk (TRISK1)	5.1854 (16.040)	—
Potential technical risk (TRISK2)	—	3.051 (25.658)
n	1,397	1,397
R^2	.156	.321

[a] The dependent variable was the estimated implicit sample risk.
[b] Numbers in parentheses are the ratios of the coefficients to the estimated standard errors. They should not be compared with critical values from the t-distribution. Here they are simply used as gauges of strength of association.

Two conclusions can be drawn from this comparison. First, if we accept the models of perception and of technical risks used to form these estimates, then the information materials did lead to systematic movements in the perceived risk message in relation to the estimated technical risk. Second, the positive intercept indicates that there is a tendency to overstate the risk message contained in the information materials. Because the risk coefficient (or slope) is greater than unity, the overstatement is accentuated at higher levels of risk.* Of course, the sample includes homeowners receiving the fact sheet who clearly overstated their perceived risk relative to the technical risk estimates.

6.2.2 Comparison 2: Posterior Risk Perceptions and Technical Risks

The second comparison with the technical risk estimates does not use the behavioral model of risk assessment. Instead, whether a policy is effective is judged by its effects on outcomes--in this case, the risk perceptions individuals stated not the risk measure communicated. Our first approach evaluates an information program as successful if people got the message right, even if they then ignored it. The second approach requires that households' final perceptions be consistent with the information provided (and ultimately take mitigating actions if then warranted by their exposure). Therefore, we directly compare the posterior risk perceptions with the two technical risk estimates.

---

*The way risk perceptions were elicited leads to important qualifications that are described in the next section.

The results are given in Table 6-2 for both measures of technical risks. To interpret the results, if the perceived risk corresponded to the individuals' estimated technical risks, then we would expect the intercept term would not be statistically different from one-ninth, the lowest perceived risk that could be stated. In Models 1 and 4, which include only the technical risk estimate, the intercept terms are positive and statistically different from one-ninth, implying that individuals overstate their incremental lifetime risks at any level of technical risk. The slope coefficients indicate that the degree of overstatement expands with increases in objective (or technical) risks. The results for the potential measures of technical risk, which account for differences in life expectancy, imply about one-half as much overstatement as the current risk estimates (slope coefficient of 2.89 in Model 4 versus 5.2 in Model 1). Note that the statistical tests for these models (e.g., t-ratios, F-test) are based on the assumption that the dependent variable is drawn from a normal distribution. We know this is not the case; this variable is an ordinal index of risk. Thus, the tests should be interpreted as approximate.

The low R^2 do not diminish the importance of the comparisons. Rather, it reinforces the conclusion that behavior matters. There are many factors that influence risk perceptions other than those reflected in the technical risk estimates.

Models 2 and 5 control for the influence of the brochures using the fact sheet as the standard for comparison. In Model 2, for example, only the command/quantitative (COQUANT) brochure yields a statistically significant association between perceived risks and the estimated technical risks. The negative sign shown for homeowners receiving this brochure means their perceived risks are reduced and therefore would be closer to their technical risk estimates. In Model 5, homeowners receiving either quantitative brochure overstated their risks by smaller amounts than their counterparts who received the fact sheet. Neither the qualitative brochures nor the EPA *Citizen's Guide* are statistically different from the fact sheet.

All the brochures reduce the divergence between posterior risk and differences in the potential technical risk (i.e., Model 6). The apparent estimated parameters between models with interaction versus shift variables can best be explained by examining how Model 6 would predict posterior risk. The posterior risk for respondents receiving the COQUANT information treatment in Model 6 would be related to TRISK2 by: SRISKF = .2168 + (11.7541 - 9.2498)* TRISK2 or .2168 + 2.5043 TRISK2. Models 3 and 6 show that, regardless of how the technical risks are represented, the brochures reduce the divergence between respondents' risk perceptions and these objective risk estimates.

TABLE 6-2. SUBJECTIVE vs. TECHNICAL RISKS FROM RADON[a]

Independent variables[b]	Current technical risk models			Potential technical risk models		
	(1)	(2)	(3)[c]	(4)	(5)	(6)[c]
INTERCEPT	.2362	.2521	.2291	.2264	.2480	.2168
	(36.916)	(22.999)	(32.395)	(33.683)	(22.683)	(27.977)
TRISK1	5.2302	5.6458	21.7439			
	(5.457)	(5.784)	(2.580)			
TRISK2				2.8925	3.1505	11.7541
				(7.117)	(7.538)	(3.291)
COQUANT		−.0509	−17.6224		−.0581	−9.2498
		(−2.709)	(−2.089)		(−3.103)	(−2.610)
COQUAL		−.0066	−14.8289		−.0175	−7.9675
		(−0.349)	(−1.748)		(−0.925)	(−2.252)
CAQUANT		−.0322	−19.5341		−.0417	−8.7949
		(−1.722)	(−2.294)		(−2.227)	(−2.482)
CAQUAL		−.0205	−13.7163		−.0304	−7.9960
		(−1.100)	(−1.617)		(−1.630)	(−2.260)
EPA		−.0070	−12.2284		−.0158	−9.4743
		(−0.366)	(−1.419)		(−0.831)	(−2.665)
n	1,928	1,928	1,928	1,928	1,928	1,928
R^2	.015	.020	.021	.026	.032	.030
F	29.783	6.528	6.696	50.656	10.435	10.019

[a] The numbers in parentheses below the estimated coefficients are t-ratios for the null hypothesis of no association. The sample size is larger for these models than for those in Table 6-1 because we have not dropped individuals who failed to report their perceived risks on the baseline survey.

[b] TRISK1 designates the ex post objective risk estimate and TRISK2 the ex ante objective risk estimate.

[c] The qualitative variables for information treatments enter the model in interactive form with the relevant technical risk measure, e.g., the coefficient for COQUANT in this column is for the variable TRISKi * COQUANT (i = 1,2)

Evaluating the effectiveness of the information program from this perspective leads to conclusions similar to our first evaluation. Individuals' risk perceptions move consistently with the technical risk estimates. This second type of comparison was able to gauge results of the separate brochures because they were not built into the behavioral model of risk perception that underlies our first comparison. Using models based on the potential technical risk estimate, the two best performers in terms of reducing perceived risks are the COQUANT and the EPA *Citizen's Guide*. While the latter has a somewhat larger effect than COQUANT, the difference would not be judged statistically significant.

The outcome differs somewhat using the current technical risk estimate. Here the NYSERDA quantitative brochures dominate with cajole/quantitative (CAQUANT) performing best. Thus, the overall conclusion favors the quantitative versions with clear preference for the CAQUANT using the current technical risk estimate.

6.3 BROCHURE EVALUATION: OVERALL ASSESSMENT

How effective were the brochures and fact sheet? Our response to this question at the mid-course evaluation considers the homeowners' evaluation of the brochures and fact sheet and our evaluation of how each performed on the three levels of effectiveness: learning, formation of risk perceptions, and the demand for additional information.

One standard method of evaluation is to ask homeowners to rate the information materials they received. As shown in Figure 6-1, such an evaluation is not very informative. A sizable majority of the homeowners agreed that the materials they received were easy to follow, were consistent with earlier information, and made it easy to evaluate their risks. Even 75 percent of the homeowners receiving the fact sheet agreed that it made it easy to evaluate their risks. If homeowner evaluations were the only basis for evaluating effectiveness, then we could find few differences between the information treatments. This contrasts sharply with the findings from the behavioral/analytical models that were presented in this and preceding chapters.

Turning to the results implied by these models, one overall conclusion, albeit a negative finding, stands out. The fact sheet was inferior in every respect to any of the information brochures. It was less likely to lead to correct answers on the radon quizzes; less likely to lead a person to have "learned" answers to questions repeated from the baseline on the followup survey; more likely to lead to increases in perceived risks, which are unwarranted because all radon readings were less than 1 picocurie per liter; and more likely to imply demand for additional information from a radon diagnostician, regardless of the price proposed for this service. Because the record against the fact sheet is so clearcut, we do not consider it in further comparisons. This conclusion would not have been apparent had we considered only the homeowners' evaluations. They reported it to be useful.

The overall evaluation of the brochures and fact sheet considers the findings of the three levels of effectiveness: learning, risk perception

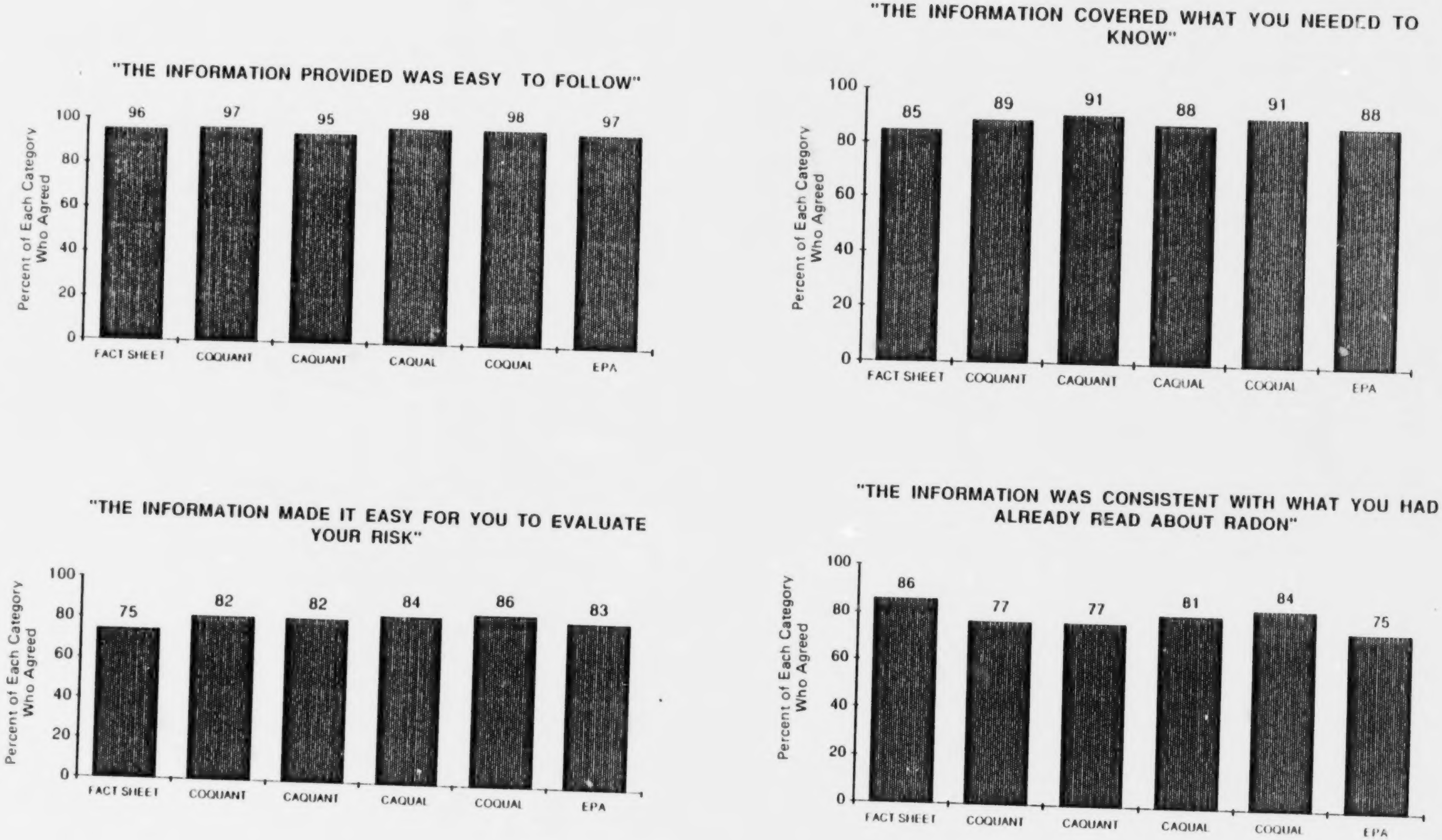


Figure 6-1. Homeowners' brochure evaluation.

formation, and the demand for information. Because none of the NYSERDA brochures and the EPA *Citizens Guide* was superior on all three levels, we compared the performance on each level separately. Only the conclusions that are based on statistically significant parameter estimates for the models in the previous chapters are discussed here. Figure 6-2 summarizes the findings from the overall evaluation.

Which Brochure Was Best?

	Learning	Risk Perception	Information Demand
COQUANT		●	●
COQUAL			●
CAQUANT		●	
CAQUAL	●		
EPA			●

Figure 6-2. Overall brochure evaluation.

6.3.1 Learning

To measure learning, we assume that brochures should increase the likelihood of correct answers. Our analysis from Chapter 3 provides two bases for evaluating learning: the total number of correct answers on the followup questionnaire and the number correct by type of question. To avoid double-counting, we have not aggregated the results because the total correct includes the individual questions.

The results are consistent between the total number of correct responses and the number correct by type of question: the NYSERDA cajole/qualitative brochure is the most successful. (Only the risk questions are considered in gauging the performance by type of question because none of the estimated parameters for the brochures' effects on correct answers to the measurement questions was statistically significant. This implies that the brochures were about the same as the fact sheet in transferring this type of information.)

The amount of learning also can be evaluated from performance on four questions that were included in both the baseline and followup surveys. One criterion is whether the brochures positively affect the likelihood an individual will "learn" (i.e., answer a question incorrectly on the baseline and correctly on the followup). Since the information was not available to respondents until after the baseline survey, we have interpreted this improvement as an indication of learning based on the materials they received. Aggregating across the four questions' significant estimates (see Table 3-5), the most opposite brochures--command/quantitative and cajole/qualitative--perform best (i.e., increase the likelihood of being in the "learn" category). Based on the magnitude of the effect, command/quantitative dominates the runner-up, with the remaining brochures distant alternatives. As shown in Figure 6-2, the composite ranking which emerges from these two categories of learning favors the cajole/qualitative format.

6.3.2 Risk Perceptions

For risk perceptions, the logic for summarizing the findings is different and somewhat more arbitrary than with the learning models. For a given radon level, we assume that a negative effect and larger (in absolute magnitude) effects are better than smaller ones because a high share of people thought they were at moderate or high risk before getting their readings (Table 4-1) and most of them turned out to have very low exposures. Thus, the information brochures should reduce the posterior risk assessments stated in the followup survey (i.e., calm fears). The record supports the quantitative versions unambiguously--both in terms of statistical significance and the magnitude of effects. The cajole/quantitative NYSERDA brochure is best, but its margin of superiority is small. Therefore, both quantitative versions have been included in the risk perception column of Figure 6-2.

6.3.3 Demand for More Information

We assume that an information brochure that leads to lower demands for additional information is better because it suggests that the materials were able to meet a homeowner's information needs. The analysis in Chapter 5 shows that all brochures reduce the likelihood of demanding a diagnostician's services (relative to the fact sheet). The EPA *Citizen's Guide* was best but its performance was only slightly better than the command versions of the NYSERDA brochures. Thus, we have included all three in the information demand column.

6.3.4 Summary

This mid-course appraisal suggests that which brochure is more effective depends on how effectiveness is measured. From the standpoint of learning, the cajole/qualitative (CAQUAL) version provides information that leads to a better intuitive understanding for answering the radon quiz. From the standpoint of helping people form subjective risk perceptions that are consistent with the technical estimates of their risks, the quantitative brochures, COQUANT and CAQUANT, were more effective. The EPA *Citizen's Guide*, and the quantitative NYSERDA brochures were most effective in reducing people's demands for more radon information. Whether any of the brochures is more effective in helping homeowners make sound mitigation decisions will be evaluated later in this research.

This mid-course evaluation also shows the need to modify the research aspect of the experiment. The dual role of our effort precludes the possibility of examining the long-term effects of the fact sheet. We know that the brochures work better in terms of calming the fears of those at low risk, so the fact sheet will be deleted from the research design. People who received a fact sheet with their interim readings will receive one of the brochures with their annual readings.

6.4 FUTURE RESEARCH

An important aspect of what will follow this mid-course appraisal is the analysis of risk perceptions and mitigation after the annual radon readings have been sent to these households. However, this is only a small part of our future research. This section highlights some opportunities for more investigation based on what we have learned so far and what we have yet to consider.

6.4.1 The Annual Readings and Followup Survey

Once the annual readings are distributed, repeating the same information treatments for each household except those who received the fact sheet, we can complete the evaluation of how radon information affects risk perception and, most importantly, whether the households act appropriately based on their risks. The second followup survey together with a subsequent contact to determine mitigation actions will permit analysis of the effects of the information brochures on these actions and the overall effectiveness of the program.

6.4.2 The Comparison Sample

The results of the followup survey for the comparison group have not been analyzed. These data were not available in time to permit analysis beyond that reported in Chapter 3. The evolution of these households' learning and risk perceptions should serve as an important benchmark in interpreting the monitored sample's responses.

We may want to draw a new comparison sample if the initial contact has caused the comparison respondents to pay more attention to radon information. If so, estimates of their learning would not be respresentative of New York State homeowners.

6.4.3 Forming Risk Perceptions

The followup survey asked a number of questions concerning how the households adjusted the risk information they received to fit their circumstances. We have not begun to examine this information for insights that might help to answer questions about why specific brochures performed well in specific aspects of our evaluation.

6.4.4 Targeted Risk Communication

Our findings provide strong support for the conclusion that people differ in how they form their risks perceptions and how they use information. Can we identify groups that respond similarly? This issue is central to improving risk communication. The conclusion that everyone is different and each responds in his own way provides no constructive basis for improving risk communication techniques.

Our findings suggest older people are different. This may be a rational response to their circumstances. On the other hand, it may reflect a need to approach them with risk information differently. If they assume at this stage "the die is cast" for their existing pattern of exposures, they may perceive mitigation as ineffective in reducing their risks. Examining subsamples systematically and the reasons for their responses is one way to begin to address these issues.

6.4.5 Refinement in Technique and Conceptual Modeling

The analysis so far provides a preview to gauge the merits of further refining our estimates and conceptual analysis. Perhaps most important, our models are largely statistical. They yield useful insights, but they are not linked together within a consistent description of the process of forming risk perceptions as part of economic behavior. This is the only way concrete hypotheses for further testing can be developed. Hypotheses follow from formal conceptual models. The design of our research to date has specifically avoided this conceptual path. Now, it appears to be warranted as a component of the overall evaluation of these households' responses.

6.4.6 Alternative Communication Channels

At this stage of the research, we have not evaluated the effectiveness of alternative communication channels, except to obtain the homeowners' assessment of how likely they would be to use various channels. While their preference for printed information in the format brochures was quite strong, we are considering several alternative channels, including town meetings, reinforcing telephone calls, and a radon diagnostician. Our final decision on these will consider the resources required, and those available, and the likelihood that a State Agency, or EPA, would be able to implement the channel as part of their functions.

6.5 IMPLICATIONS

The following important implications can be drawn from this mid-course evaluation of the NYSERDA risk communication program:

- Evaluating effectiveness requires perceptual/behavioral measures of performance because simply asking homeowners for their evaluations is misleading. Even though the homeowners themselves found the fact sheet useful, our evaluation showed lower levels of learning, higher demands for more information, and higher levels of anxiety.

- Quantitative risk information materials reduced the divergence between perceived and technical risks. The cajole/qualitative brochure helped homeowners develop a more intuitive understanding of the risk shown by higher learning and a better ability to advise their neighbors about radon risks.

- Formal channels for communicating radon risks are poorly established. Homeowners in New York are not likely to know which agency to turn to for more information about radon. Less than

8 percent would have turned to the correct Agency. Homeowners were much more likely to use informal channels--family members, friends, or neighbors--to discuss their radon results. Less than 1 percent of the homeowners contacted a government agency or public official about their radon results.

- None of the risk communication channels we have evaluated seemed to work for older people. They were less likely to intend to purchase the services of a radon diagnostician and less likely to use additional information brochures on either radon risks or mitigation. Because older people experienced problems in evaluating their risks, it is important to determine whether these responses to the diagnostic services are a rational response, given their circumstances, or reflect the need to find a more effective source for communicating risk information to them.

- Homeowners did respond to the risk information rationally. People with higher radon readings perceived their risks to be more serious than those with lower readings. Our results also showed, however, that our understanding of the relationship between perceived and technical risk estimates can be improved.

Finally, our mid-course appraisal does not address three important radon risk communication issues. One, the homeowners have not made mitigation decisions, which are needed to evaluate our fourth indicator of effectiveness. This evaluation will have to wait until after the annual radon readings are sent to the homeowners. Two, alternative communication channels will not be evaluated until after the annual radon readings are sent. Three, the homeowners in our New York panel can provide, at most, indirect information for EPA on the decision of homeowners to test for radon. These homeowners decided to test because they were asked to participate in the NYSERDA measurement study. The testing issue remains an important consideration in the overall effectiveness of a radon risk information program.

6.6 REFERENCES

Fischhoff, Baruch, Paul Slovic, Sarah Lichtenstein, Stephen Reed, and Barbara Combs, 1978, "How Safe is Safe Enough? A Psychometric Study of Attitudes Toward Technological Risk and Benefits," *Policy Sciences,* Vol. 9, pp. 127-52.

Russell, Milton, 1986, Speech to Workshop on Reporting of Health Risk Information by Television, Columbia School of Journalism, New York, New York, April 22.

Slovic, Paul, Baruch Fischhoff, and Sarah Lichtenstein, 1980, "Facts vs. Fears: Understanding Perceived Risk," in R. Schwing and W. Albers, eds., *Societal Risk Assessment: How Safe Is Safe Enough?* New York: Plenum Publishers.

Appendix A

Radon Measurements and Research Design

APPENDIX A

RADON MEASUREMENTS AND RESEARCH DESIGN

As part of the overall NYSERDA radon measurement study, households received a varying number of alpha-track monitors or detectors for measuring radon. There are nine possible detector designations:

1. Main living area, 2-month detector
2. Duplicate living area, 2-month detector
3. Blank or covered living area, 2-month detector
4. Main living area, 12-month detector
5. Duplicate living area, 12-month detector
6. Blank or covered living area, 12-month detector
7. Main basement, 12-month detector
8. Duplicate basement, 12-month detector
9. Covered or blank, 12-month basement detector.

Each participant in the radon study received at least two monitors, Types 1 and 4, and, if the residence had a basement, the participant also received a Type 7 detector. The other detectors were assigned to serve as a check on the accuracy of the main detectors. For this report, our analysis is concerned only with the "2-month" monitors, designed to measure winter radon levels. Households were supposed to return these short-term detectors to the Research Triangle Institute (RTI), who sent the monitors to Terradex for analysis. The results were then sent to RTI. For the radon information effectiveness study, we sent households their average winter radon reading, along with some information about radon, its effects, and how to reduce household radon levels.

The average radon reading depends on the type and number of detectors a household received: for households with only a Type 1 short-term detector or with a Type 1 and a Type 3, the average reading is the reading recorded for the Type 1 detector. If, on the other hand, the household sent in two detectors, Types 1 and 2, the household radon level is reflected by the average of the readings for the two detectors.

As discussed in Appendix B, the first step in our experiment involved dividing the sample into two groups: households with mean radon readings below 1 picocurie per liter and households with readings above 1 picocurie per liter. During the first part of November, while we were preparing to mail out the radon readings and information materials, the RTI statisticians conducting the measurement study changed their assessment of detectors, which affected some of the readings in our sample. The problem arose because some survey participants had incorrectly recorded the monitor installation and removal dates. Because the interpretation of the radon levels depends critically on how long the detectors were exposed to radon in the home, changing the installation and removal dates altered the resulting radon reading. These individuals had, in general, written the same year for the installation and removal dates, resulting in removal dates earlier than the installation dates. Once the mistake was corrected, the radon levels were recalculated, and the statisticians provided the new readings.

While making these corrections, we decided to check that all of the radon readings in our file corresponded with those in the statisticians' files. Our analysis showed 39 discrepancies between the two files, of which 17 were not participants in our information effectiveness study, because they had returned their detectors too late to be included. The discrepancies arose because the statisticians had reclassified some Type 2 monitors as "uncovered Type 3" monitors, which implied that these monitors should not be included in calculating the household's mean radon reading. Of the survey participants whose readings changed, only two presented problems in terms of the experimental design. As noted above, the initial step in the process of assigning households to design points involved splitting the sample into those households with radon readings below 1 piC/l and those with radon readings above 1 piC/l. Two of the households' revised radon readings moved them from one-half of the sample to the other. We reassigned these households to design points by randomly drawing two design points. We recalculated the randomness diagnostics to ensure that no bias had been imparted.

Appendix B

Design Implementation

APPENDIX B

DESIGN IMPLEMENTATION

The first step in implementing the experimental design for evaluating the effectiveness of alternative information treatments was assigning survey respondents to one of eleven treatment groups:

	Condition or Treatment Group					
	Fact sheet	COQUANT	CAQUANT	CAQUAL	COQUAL	EPA Citizen's Guide
Radon reading < 1 picocurie per liter	0	1	2	3	4	5
Radon reading > 1 picocurie per liter		6	7	8	9	10

We first divided our sample of households that participated in the baseline survey into two groups: households with radon readings below 1 picocurie per liter and households with radon readings of 1 or more picocuries per liter. We then randomly assigned the households with radon readings below 1 picocurie per liter to one of two groups. Half of them received only the fact sheet. The other half received one of the five information brochures (i.e., the four project-designed brochures and the EPA Citizen's Guide). The households with radon readings over 1 picocurie per liter were randomly assigned to five groups of equal size. Each of these respondents received one of the same five brochures. In addition to the radon information brochures, each household in the 1-picocurie-or-above category also received the EPA radon mitigation booklet, Radon Reduction Methods: A Homeowner's Guide.

To allocate households in each component of the sample to these treatment groups, a random number generator was used to assign a random number to each household. We then sorted the households by random number.* After sorting the sample according to random numbers, the "under-ones" and "over-ones" were divided into treatment groups (conditions) based on the order of their random numbers. For example, the under-one part of the sample contained 1,290 households. Each time the sample was sorted by random number, the 645 households with the lowest random numbers were assigned to Condition 0, to receive the fact sheet. The next 129 were assigned to Condition 1, the next 129 to Condition 2, and so on.

To guarantee that the sorting resulted in an allocation of the sample that was independent of the key characteristics of the households in each group, we performed several statistical tests for independence. The main objective was to avoid confounding between the final assignment and differences among the individuals in the group. For example, we did not want only people with high radon readings or high levels of perceived risks in one treatment group. While all the assignments we tried were random, the sample sizes were small enough that interdependencies did result between key variables and the assignment. We therefore checked for these interdependencies each time we randomly assigned households to the various conditions. As it turned out, the under-ones required more than a dozen randomizations before a sample division passed all the tests, and the over-ones required nearly two dozen randomizations before a satisfactory randomization was achieved.

In the statistical tests, we required that there be no relationship between the design assignment, or condition, and the households' characteristics. If such a relationship were found to exist, the sorting by random number was repeated, and the tests performed again. The first test run on all categorical variables was a cross-tabulation of the baseline survey data on the households by condition. The randomization was considered to have passed this test if the Chi-square tests run on the two-way frequency tables showed no relationship between the two variables being tabulated. Table B-1 shows an example of these two-way frequency tests for income and condition.

---

*The random number generator used takes the computer clock as its starting point or "seed" and "returns a number generated from the uniform distribution on the interval (0,1), using a prime modulus multiplicative generator with modulus 231-1 and multiplier 397204094 (SAS User's Guide: Basics [1982], available from SAS Institute, Cary, NC). Because the random number generator uses the computer clock to initialize the random number stream, a different allocation of the sample occurs each time the program is run.

TABLE B-1. COMPARISON OF CONDITIONS TO HOUSEHOLDS: TWO-WAY FREQUENCY TABLE[a]
(Table of Income by Condit)

Income/ frequency	Under 1 picocurie						
	Condit.						
	0	1	2	3	4	5	Total
$80,001 and over	28	6	0	12	12	8	66
5,000	10	4	2	0	3	0	19
10,000	76	15	21	9	14	22	157
20,000	143	23	29	24	27	25	272
30,000	141	28	27	31	26	31	284
42,500	113	29	19	27	23	22	233
57,500	50	11	14	12	12	11	110
72,500	27	2	6	6	6	1	48
Total	588	118	118	121	123	120	1,188

Frequency missing = 102

STATISTICS FOR TABLE OF INCOME BY CONDIT

Statistic	DF	Value	Prob
Chi-square	42	46.249	0.301
Likelihood ratio chi-square	42	56.056	0.072
Mantel-Haenszel chi-square	1	0.665	0.415
PHI		0.197	
Contingency coefficient		0.194	
Cramer's V		0.081	

Effective sample size = 1,118
Frequency missing = 102
Warning: 32% of the cells have expended counts less than 5. Chi-square may not be a valid test.

Income/ frequency	Over 1 picocurie					
	Condit.					
	6	7	8	9	10	Total
$80,001 and over	12	4	7	6	6	35
5,000	3	3	2	4	1	13
10,000	23	25	30	16	23	117
20,000	35	31	40	51	45	202
30,000	49	59	47	48	32	235
42,500	44	39	43	39	41	206
57,500	18	15	10	14	26	83
72,500	7	4	6	6	4	27
Total	191	180	185	184	178	918

Frequency missing = 90

STATISTICS FOR TABLE OF INCOME BY CONDIT

Statistic	DF	Value	Prob
Chi-square	28	35.837	0.147
Likelihood ratio chi-square	28	35.586	0.153
Mantel-Haenszel chi-square	1	0.215	0.643
PHI		0.198	
Contingency coefficient		0.194	
Cramer's V		0.099	

Effective sample size = 918
Frequency missing = 90

---

[a] Cross-tabulation of income by treatment group assignment.

For the more continuous variables in our experiment, the Chi-square test was unreliable because some of the cells contained less than 5 percent of the sample. These variables were age, income, last grade completed in school, years lived at this address, radon reading, the number of times a respondent heard about radon in the last 3 months, and several measures of performance on the radon test questions. On these variables, we ran ordinary least-squares (OLS) models, with "condition" as the explanatory variable. Again, the randomization was considered acceptable if there were no statistically significant relationships between any of the dependent variables and the independent variable for the design point assignment. The results of these regressions are shown in Table B-2.

TABLE B-2. COMPARISON OF CONDITIONS TO HOUSEHOLDS: OLS REGRESSIONS[a]

Under 1 picocurie				Over 1 picocurie			
Dependent variable[b]	Type I SS	F value	DF	Dependent variable	Type I SS	F value	DF
TOT_COR	56.40	1.11	6	TOT_COR	16.88	0.48	4
TOT_DK	43.64	0.59	6	TOT_DK	38.57	0.76	4
MEANREAD	0.27	0.73	6	MEANREAD	36.63	0.63	4
TIMEHEAR	2.12	0.64	6	TIMEHEAR	12.06	0.38	4
SER_RADO	0.30	1.15	5	SER_RADO	0.36	1.79	4
ADDRLIVE	1,094.98	1.37	6	ADDRLIVE	574.94	0.90	4
AGE	951.75	0.77	6	AGE	465.73	0.54	4
LASTGRAD	33.47	0.94	6	LASTGRAD	12.78	0.53	4

[a] Dependent variable: baseline survey responses that are continuous or have many categories.

Independent variable: treatment group assignment.

[b] TOT_COR--total correct on quiz; TOT_DK--total don't know; MEANREAD--mean radon reading; TIMEHEAR--number of times homeowner had heard about radon; SER_RADO--perceived seriousness of risk from radon; ADDRLIVE--number of years lived at current address; AGE--person's age; LASTGRAD--person's last grade completed.

As a final step in checking our randomizations, we ran regressions testing for relationships between a dummy variable representing treatment group assignment and several variables we considered critical. These variables are shown, along with their variable names, in Table B-3. Again, we accepted the randomization if we found no statistically significant relationships between any of the independent variables and the dummy variable representing condition. The results from these regressions are shown in Table B-4. Because the OLS regressions showed no evidence of relationships, we did not conduct more sophisticated analyses such as probits.

TABLE B-3. VARIABLES INCLUDED IN DUMMY-VARIABLE REGRESSIONS

Variable name	Variable definition
INCOME	Before-tax annual income
LASTGRAD	Last grade of regular school completed
AGE	Age
SEX	Sex
MEANREAD	Radon reading
RISK_COR	Composite score on risk questions from baseline survey
TIMEHEAR	Times heard about radon in the last 3 months
USE_BROC	Want information in a brochure mailed to house
CONC_CIT	Radon is a serious concern in your city or town
CONC_NEI	Radon is a serious concern in your neighborhood
CONC_EXA	Concern about radon is greatly exaggerated
SIM_WAST	Risk of dying from radon similar to risk from hazardous waste dump
ADDRLIVE	Years lived at this address
NUMPEOP	Number of people living at this address
FIXHOUSE	Usually try to fix things around the house
ASK_DOC	Question doctor, read health articles
INFO_APP	Gather logs of information before buying appliances
QUES_INF	Question information from experts or authorities
NUM_WORK	Work with numbers in job or hobby

TABLE B-4. ORDINARY LEAST SQUARES REGRESSIONS[a]

Variable name	Dependent variable							
	Design #0		Design #1		Design #2		Design #3	
	Parameter estimate	T value	Parameter estimate	T value	Parameter estimate	T value	Parameter estimate	T value
INTERCEP	0.5752	3.259	0.1054	1.010	0.0935	0.896	0.0947	0.873
INCOME	0.0000	-0.866	0.0000	-0.479	0.0000	1.254	0.0000	0.288
LASTGRAD	-0.0006	-0.071	-0.0002	-0.039	-0.0021	-0.442	0.0022	0.428
AGE	-0.0011	-0.622	0.0003	0.246	0.0002	0.160	0.0005	0.477
SEX	0.0206	0.527	0.0087	0.376	-0.0232	-1.004	0.0095	0.394
MEANREAD	0.0602	0.821	-0.0288	-0.664	0.0374	0.863	-0.0691	-1.532
RISK_COR	0.0070	0.375	0.0012	0.105	-0.0094	-0.849	-0.0138	-1.199
TIMEHEAR	0.0005	0.081	-0.0056	-1.526	0.0054	1.461	0.0006	0.156
USE_BROC	-0.0430	-1.473	0.0056	0.327	0.0094	0.544	-0.0232	-1.297
CONC_CIT	-0.0031	-0.056	-0.0190	-0.587	-0.0202	-0.624	0.0376	1.117
CONC_NEI	0.0232	0.390	0.0105	0.299	0.0375	1.067	-0.0532	-1.456
CONC_EXA	-0.0029	-0.057	0.0219	0.723	0.0032	0.105	0.0248	0.788
SIM_WAST	-0.0469	-1.100	-0.0028	-0.112	0.0282	1.118	0.0258	0.986
ADDRLIVE	0.0028	1.402	0.0003	0.244	-0.0014	-1.196	-0.0015	-1.167
NUMPEOP	0.0034	0.243	0.0032	0.387	-0.0054	-0.646	0.0142	1.651
FIXHOUSE	-0.0050	-0.129	0.0186	0.801	-0.0261	-1.123	0.0063	0.261
ASK_DOC	0.0250	0.624	-0.0131	-0.556	0.0226	0.955	-0.0203	-0.826
INFO_APP	-0.0638	-1.607	-0.0191	-0.812	0.0104	0.444	0.0193	0.789
QUES_INF	0.0147	0.357	-0.0011	-0.044	0.0108	0.442	-0.0047	-0.184
NUM_WORK	0.0227	0.588	-0.0018	-0.078	-0.0324	-1.420	-0.0093	-0.393
F VALUE	0.573		0.337		0.788		0.845	
PROB>F	0.9262		0.9965		0.7235		0.6533	
R-SQUARE	0.0143		0.0084		0.0196		0.0209	
ADJ. R-SQUARE	-0.0106		-0.0166		-0.0053		-0.0038	

[a] Dependent variables: dummy variables representing treatment group assignment.
Independent variables: characteristics of respondents.

(continued)

TABLE B-4 (continued)

Variable name	Dependent variable							
	Design #4		Design #5		Design #6		Design #7	
	Parameter estimate	T value	Parameter estimate	T value	Parameter estimate	T value	Parameter estimate	T value
INTERCEP	0.1733	1.556	-0.0420	-0.415	0.3573	2.089	-0.0590	-0.370
INCOME	0.0000	0.646	0.0000	-0.307	0.0000	-0.369	0.0000	1.511
LASTGRAD	-0.0028	-0.545	0.0036	0.761	-0.0092	-1.202	0.0008	0.111
AGE	0.0003	0.299	-0.0002	-0.174	0.0018	1.097	0.0006	0.372
SEX	-0.0181	-0.736	0.0026	0.114	0.0227	0.597	-0.0032	-0.089
MEANREAD	-0.0480	-1.038	0.0482	1.145	-0.0055	-1.044	-0.0029	-0.595
RISK_COR	0.0087	0.734	0.0064	0.590	0.0116	0.632	0.0070	0.409
TIMEHEAR	-0.0011	-0.273	0.0002	0.058	0.0044	0.791	-0.0016	-0.305
USE_BROC	0.0124	0.674	0.0388	2.318	-0.0137	-0.499	0.0307	1.198
CONC_CIT	0.0207	0.599	-0.0160	-0.509	-0.0246	-0.450	-0.0049	-0.096
CONC_NEI	-0.0280	-0.747	0.0100	0.292	-0.0160	-0.271	0.0255	0.463
CONC_EXA	-0.0112	-0.347	-0.0357	-1.215	-0.0880	-1.764	0.0062	0.133
SIM_WAST	-0.0013	-0.048	-0.0030	-0.123	-0.0314	-0.792	0.0655	1.771
ADDRLIVE	-0.0011	-0.882	0.0009	0.756	-0.0017	-0.900	-0.0001	-0.083
NUMPEOP	-0.0109	-1.236	-0.0046	-0.566	0.0063	0.464	0.0130	1.023
FIXHOUSE	-0.0110	-0.446	0.0173	0.766	0.0063	0.169	-0.0134	-0.384
ASK_DOC	-0.0053	-0.210	-0.0088	-0.383	0.0466	1.225	-0.0133	-0.375
INFO_APP	0.0287	1.147	0.0245	1.074	-0.0042	-0.114	0.0077	0.223
QUES_INF	-0.0053	-0.205	-0.0144	-0.610	-0.0402	-1.043	0.0289	0.802
NUM_WORK	0.0027	0.110	0.0182	0.818	-0.0187	-0.495	0.0356	1.010
F VALUE	0.436		0.686		0.679		0.647	
PROB>F	0.9827		0.8356		0.8415		0.8707	
R-SQUARE	0.0109		0.0171		0.0218		0.0208	
ADJ. R-SQUARE	-0.0141		-0.0078		-0.0103		-0.0113	

(continued)

TABLE B-4 (continued)

Variable name	Dependent variable					
	Design #8		Design #9		Design #10	
	Parameter estimate	T value	Parameter estimate	T value	Parameter estimate	T value
INTERCEP	0.1090	0.682	0.1052	0.682	0.4875	3.128
INCOME	0.0000	-0.966	0.0000	-0.729	0.0000	0.571
LASTGRAD	0.0059	0.816	0.0030	0.436	-0.0004	-0.063
AGE	-0.0010	-0.673	-0.0002	-0.155	-0.0011	-0.741
SEX	-0.0284	-0.799	0.0068	0.198	0.0020	0.059
MEANREAD	0.0089	1.829	0.0046	0.973	-0.0052	-1.084
RISK_COR	-0.0126	-0.734	-0.0048	-0.290	-0.0012	-0.071
TIMEHEAR	0.0024	0.462	-0.0024	-0.468	-0.0029	-0.566
USE_BROC	-0.0101	-0.393	0.0148	0.596	-0.0217	-0.866
CONC_CIT	0.0222	0.435	0.0085	0.173	-0.0012	-0.025
CONC_NEI	0.0086	0.156	0.0180	0.338	-0.0361	-0.671
CONC_EXA	0.0621	1.333	0.0823	1.826	-0.0626	-1.375
SIM_WAST	0.0164	0.441	-0.0212	-0.594	-0.0292	-0.809
ADDRLIVE	0.0043	2.482	-0.0024	-1.420	-0.0001	-0.065
NUMPEOP	0.0078	0.612	-0.0021	-0.168	-0.0250	-2.018
FIXHOUSE	-0.0401	-1.145	0.0531	1.570	-0.0059	-0.173
ASK_DOC	0.0444	1.249	0.0026	0.076	-0.0803	-2.316
INFO_APP	0.0193	0.557	-0.0057	-0.171	-0.0171	-0.505
QUES_INF	-0.0058	-0.160	0.0383	1.100	-0.0212	-0.602
NUM_WORK	-0.0519	-1.469	0.0598	1.754	-0.0248	-0.721
F VALUE	0.944		1.029		1.067	
PROB>F	0.5273		0.4252		0.3818	
R-SQUARE	0.0301		0.0327		0.0338	
ADJ R-SQUARE	-0.0018		0.0009		0.0021	

Appendix C

Sample Design and Allocation and Sample Size Justification

APPENDIX C

SAMPLE DESIGN AND ALLOCATION AND SAMPLE SIZE JUSTIFICATION

C.1 SAMPLE DESIGN AND ALLOCATION

C.1.1 Stratification

Stratification consists of partitioning the units of the study population into nonoverlapping subgroups, or strata. The total sample is then allocated among the strata, and the required number of units is selected from each stratum. For the statewide radon study, single-unit homes in New York State have been stratified into seven geographical areas, or strata. The strata and allocation of the total sample of 2,500 homes among the strata are described in this appendix. (The sample for the risk communication research included only the 2,300 homeowners who returned their radon monitors.)

Stratification provides control of the distribution of the sample. There are several reasons why such control may be desired, and reasons pertinent to the statewide radon survey are briefly discussed here. One reason for stratification is to improve the precision of sample estimates. Toward this end, stratification variables suspected to be related to the response variable (here, radon level) are chosen; that is, strata are formed to reflect anticipated differences in the response variable. Precision is improved to the extent that population units in the same stratum tend to have similar response variable values, and stratum averages tend to be different. A second reason for controlling the distribution of the sample is to facilitate estimation for subpopulations of interest (referred to as domains). Strata, or combinations of strata, can be defined to coincide with domains, and the required sample size can then be assigned to each domain. Another reason for stratification is to distribute the sample so that data users are assured that primary groups in the study population are adequately represented. This may be important even when separate estimates for these groups are not needed and differences (with respect to the response variable) are not suspected. Such dispersion of the sample is frequently a motivation for using some level of geographical stratification in statewide or national surveys.

It follows that developing strata for the statewide radon survey involved considering what factors may be related to radon levels and what subpopulations may be of special interest to the study. According to current technical literature, the major source of radon in United States houses is the underlying soil; thus, indoor radon concentrations are determined (to a first order) by soil radium concentrations and soil permeability. Soil types generally reflect underlying geological conditions and are therefore spatially coherent (i.e., similar rocks and soils will be exposed in areas with characteristic dimensions from hundreds of meters to hundreds of kilometers in extent). These observations recommend stratification according to location. Specifically, stratification into major geological regions is appropriate, together with additional stratification to delineate other areas of special interest to the study.

Following discussions with NYSERDA and geological consultants, the following strata were selected for the radon survey:

1. Binghamton. Based on NURE data, this is an area of special interest. High levels of radon have been observed in water.

2. Undeformed Sediments. Relatively undeformed Paleozoic sediments dominate central and southern New York, from Albany to Buffalo, and south to Binghamton. NYSERDA data indicate that some high radon concentrations have been found in this region. In addition, investigations by Sachs and others have shown that undeformed sediments can be associated with high radon concentrations in Pennsylvania, on rocks which may not be dissimilar to the New York exposures.

3. Metamorphic Rock. The Adirondack metamorphic/igneous rocks contain facies analogous to those associated with high radon concentrations in water in Maine.

4. Deformed Sediments and Rock. East of Albany, and extending down to New York City, there is a belt of complex deformed, orogenic sediments and metamorphic rocks, which is considered a discrete geological region.

5. Staten Island. Staten Island is in part underlain by Triassic sediments similar to those associated with unusually high concentrations of radon in the Princeton, New Jersey, area.

6. Long Island. Much of Long Island is underlain by glacial sediments. It has a very large population base, but radon levels should be low in this area containing predominantly sand deposits.

7. New York City. This is not a separate geological region, but the size of the city warrants its individual consideration.

C.1.2 Allocation of the Sample Size

This section describes the allocation of the first stage sample (clusters of homes) to the seven geographical strata, and the size of the second stage sample (homes) to be selected from each cluster. For these purposes, equations are used that express:

- The sampling variance of the parameter estimates
- The cost of the survey

in terms of design constants and the first and second stage sample sizes. These equations are solved for the sample sizes needed to satisfy the variance constraints, for a minimum cost. The design constants and the variance for this survey are described below.

The resulting allocations differ, however, since some of the design constants are different. There have been changes in design constants because the stratum definitions have been refined and the study population has been restricted to include only single-unit homes (instead of all households).

Allocations are presented for two separate sets of variance constraints. For allocation I, variance constraints are imposed on statewide estimates and on estimates for Strata 1, 2, and 3. Allocation II results from variance constraints on statewide estimates and on estimates for Strata 1, 2, 3, and 5 (Staten Island). Allocation II would be warranted if there were special interest in studying radon levels in Staten Island homes (i.e., interest beyond that appropriate for a stratum comprising only 2 percent of the statewide study population).

The following design constraints are involved in allocating the sample size:

1. The population proportion. Statewide and for each stratum. This is the proportion of single-unit homes having radon levels that exceed a specified value of interest. The allocation is developed to give precise estimates for proportions in the neighborhood of .05. (Estimates will be of better precision for proportions greater than .05).

2. Relative stratum sizes. The relative size of a stratum is the ratio of the number of single-unit homes in the stratum to the number of single-unit homes in the State. These values were computed using 1980 county-level census information on the total number of housing units and the proportion of single-unit structures. Table C-1 displays the relative stratum sizes.

3. The cost of an unproductive telephone number (i.e., one not yielding a single-unit home), and the cost of a completed telephone interview with a single-unit household.

4. The probability of identifying a cluster from a randomly selected telephone number. This probability varies from stratum to stratum. Its value was estimated for each stratum based on the number of NPA/NXX codes, the number of households, and the percentage of households that are single-unit. The estimates are shown in Table C-1.

5. The conditional probability of obtaining a single-unit home within an identified cluster. Again, this probability varies from stratum to stratum. Its values given in Table C-1 were taken from previous RTI experience in random digit dialing for the respective locations and adjusted to account for this study's restriction to single-unit homes.

6. The intracluster correlation. This design constant describes the tendency for homes in the same cluster to have similar radon levels. Its value is assumed to be .05 for all strata. This value was chosen based on previous survey experience and on certain features of this study. In particular, homes in the same cluster will be relatively close in location and so will be more likely (although not at all certain) to have similar underlying geological conditions that may be related to radon levels. Also, homes in the same cluster may tend to be somewhat similar in age and "tightness" (with respect to ventilation), a factor suspected to be related to indoor radon levels.

Having specified the design constants, the sample size solutions are obtained in two steps. The optimal second stage sample sizes (i.e., the number of single-unit homes per cluster) for each stratum are computed first. These optimal cluster sizes do not depend on the variance constraints, and thus are the same for both allocations I and II. The computer cluster sizes have been adjusted upwards to compensate for the following anticipated nonresponse: (1) a failure to obtain the required information about housing unit characteristics for 5 percent of the households and (2) a further failure to obtain the radon information in 15 percent of the households. The resulting second stage sample sizes are shown in Table C-2.

TABLE C-1. DESIGN CONSTANTS

Stratum h	Relative stratum size (single-unit homes) $N(h)/N)$	Probability of identifying a cluster $p(h)_c$	Probability of identifying a single-unit home, given a cluster $p(h)_r$
1. Binghamton	.031	.19	.23
2. Undeformed sediments	.417	.15	.29
3. Metamorphic rock	.047	.13	.26
4. Deformed sediments and rock	.140	.16	.26
5. Staten Island	.021	.29	.32
6. Long Island	.241	.25	.37
7. New York City	.103	.08	.10

TABLE C-2. SAMPLE SIZE ALLOCATION I: VARIANCE CONSTRANTS ON STATEWIDE ESTIMATES AND ON STRATA 1, 2, AND 3 ESTIMATES

Stratum	First stage sample size (clusters)	Second stage sample size (housing units) per cluster)	Total sample size (housing units)	Expected telephone numbers	
				To identify clusters	Total
1. Binghamton	156	2	312	821	1,499
2. Undeformed sediments	232	3	696	1,547	3,147
3. Metamorphic rock	160	3	480	1,231	2,462
4. Deformed sediments and rock	78	3	234	488	1,088
5. Staten Island	24	2	48	83	158
6. Long Island	272	2	544	1,088	1,823
7. New York City	48	3	144	600	1,560
State	970	-	2,418[a]	5,858	11,737

[a] Taking into account anticipated nonresponse, this sample size is expected to yield approximately 2,000 complete observations.

Given the second stage sample sizes, the first stage sample sizes (i.e., number of accepted clusters) for each stratum required to meet the variance constraints can now be computed. The variance constraints are specified in terms of the coefficient on variation (CV), which is defined as

$$CV\ \{\hat{P}\} = \frac{[Var\{\hat{P}\}]}{P}^{1/2},$$

where P is the population proportion being estimated, $\hat{P}$ is the estimator based on the sample data, and Var$\{\hat{P}\}$ is the variance of $\hat{P}$. The variance constraints are imposed at P = .05 for this design, as discussed earlier.

The following variance constraints are used to obtain the first allocation:

$$\begin{aligned} CV\{\hat{P}\} &\leq .13 && \text{(statewide);} \\ CV\{\hat{P}(1)\} &\leq .35 && \text{(Stratum 1);} \\ CV\{\hat{P}(h)\} &\leq .25, && h = 2, 3; \text{ and} \\ CV\{\hat{P}(h)\} &\leq 1.00, && h = 4, 5, 6, 7. \end{aligned}$$

The strongest constraint is placed on the variance of the statewide estimate. Constraints are also imposed for Strata 1, 2, and 3 estimates, because these strata are of special interest to the study, beyond their contribution to statewide estimates. Variances for the remaining stratum-level estimates are only minimally constrained. It should be noted that a CV of .13 when P = .05 is equivalent to a 95 percent confidence interval half-length of .013. A CV of .25 is equivalent to a confidence interval half-length of .024, and for .35 the half-length equals .034.

The sample allocation solutions to the above constraints are shown in Table C-2. Also shown in Table C-2 are the expected number of telephone numbers required to obtain the specified number of sample clusters and sample housing units. Under the Mitofsky/Waksberg procedure, the number of telephone numbers is a random variable. The fixed sample size is the total of 2,458 housing units, from which complete information is expected to be obtained from about 2,000.

The second allocation uses the following variance constraints:

$CV\{\hat{P}\} \leq .14$ (statewide);
$CV\{\hat{P}(h)\} \leq .35,\quad h = 1, 5;$
$CV\{\hat{P}(h)\} \leq .25,\quad h = 2, 3;$ and
$CV\{\hat{P}(h)\} \leq 1.00,\quad h = 4, 6, 7.$

Compared to the first allocation, a stronger constraint has been imposed for Stratum 5, Staten Island. The solutions corresponding to these constraints are presented in Table C-3.

The difference between the two proposed allocations is the number of housing units selected from Staten Island. When the study was initiated, Staten Island was an area where no data were available on radon levels in homes. However, since approximately 50 percent of the land area is shale and high radon levels in homes have been detected in similar geological areas in New Jersey, it is reasonable to expect the homes in Staten Island could have high radon levels.

In order to get some information on radon levels in homes in Staten Island, a prepilot for this task was performed in Staten Island. If homes with high radon levels were found, then the second allocation would be used (156 homes in Staten Island). On the other hand, if no homes with high radon levels were found, then the first allocation (24 homes in Staten Island) would be utilized for the statewide survey.

C.2 SAMPLE SIZE JUSTIFICATION

One approach for using the survey information requires that we consider many of the parameters to be estimated in this study as proportions, e.g., the proportion of households that undertake mitigation activities. Accordingly, the proposed sample sizes were determined by computing the sample size required to estimate proportions of the underlying population (i.e., households in New York State).

The required sample size depends upon the desired precision of the proportion estimates. The sample size required to produce an estimate, $\hat{p}$, that is within δ units of the true population proportion, p, with α percent certainty depends upon δ, p, and α. Clearly, it is desirable to make δ small and α large. However, decreasing δ and increasing α each requires an

TABLE C-3. SAMPLE SIZE ALLOCATION II: VARIANCE CONSTRANTS ON STATEWIDE ESTIMATES AND ON STRATA 1, 2, 3, AND 5 (STATEN ISLAND) ESTIMATES

Stratum	First stage sample size (clusters)	Second stage sample size (housing units) per cluster)	Total sample size (housing units)	Expected telephone numbers	
				To identify clusters	Total
1. Binghamton	156	2	312	821	1,499
2. Undeformed sediments	196	3	588	1,307	1,658
3. Metamorphic rock	160	3	480	1,231	1,462
4. Deformed sediments and rock	66	3	198	412	920
5. Staten Island	156	2	312	538	1,025
6. Long Island	230	2	460	920	1,542
7. New York City	41	3	123	513	1,332
State	1,005	-	2,473[a]	5,742	11,438

[a] Taking into account anticipated nonresponse, this sample size is expected to yield approximately 2,000 complete observations.

increase in the required sample size. Additionally, a δ value that is considered precise for large p values is not necessarily precise for small p values. For example, let $\delta = .10$, $\hat{p}_1 = .85$, and $\hat{p}_2 = .05$. Then, $\hat{p}_1 \pm \delta$ is equal to .85 ± .10 which is relatively precise. However, $\hat{p}_2 \pm \delta$ which is equal to .05 ± .10 is not very precise.

Table C-4 shows the sample sizes needed to detect a specific difference with power $1 - \beta$. The important specific differences for this information collection will be the differences in estimated mitigation expenditures for households that receive the alternative information treatments. Differences in estimates of perceived and actual risks from radon among the same groups will also be important.

An example using estimated coefficients of variation, which are equal to the standard error of the estimate divided by the mean estimate will explain Table C-4. Suppose the coefficient of variation for estimated mitigation expenditures is equal to .2, then a sample size of 68 is necessary to detect a 10-percent difference in the mean value. In this case, there is a 95-percent confidence that the difference is not zero and a 10-percent chance of not rejecting the null hypothesis ($\Delta = 0$) when it is false. If there is little or no variation in the estimates, then small differences can be detected with minimal sample size. Considerable variation in estimated values, however, will mean that a small sample may not be able to detect small differences in the estimates. Thus, when estimating proportions, relative precision is often considered as the most appropriate basis for determining the sample size. This is accomplished by requiring that $\hat{p}$ lie within $p\delta$ units of the true p value with α percent certainty for smallest proportion of interest. In the above example, the estimate of the small p value would change from .05 ± .10 to .05 ± .005 which is a much more precise estimate. Obviously, this method significantly increases the required sample sizes for small p values.

Table C-5 contains minimum sample sizes for $\hat{p}$ to be within $p\delta$ units of p with 95 percent certainty (in the sense of repeated sampling) for various values of p and δ, assuming simple random sampling. The p values to be estimated in the study are unknown and will probably vary considerably from one activity to another. Therefore, it is impossible to determine exactly the appropriate sample size. Because past work on measuring radon mitigation

TABLE C-4. SAMPLE SIZES NEEDED TO DETECT A SPECIFIED DIFFERENCE WITH POWER $1 - \beta$

(a) α = Type I Error = .05, β = Type II Error = .1

	CV = Coefficient of Variation (σ_e/μ_c)[a]				
Detection level (Δ)	.1	.2	.3	.4	.5
.06 μ_c	48	190	428	760	1,189
.08 μ_c	27	107	241	428	669
.10 μ_c	17	68	154	274	428
.15 μ_c	8	30	68	122	190
.20 μ_c	4	17	39	68	107
.25 μ_c	3	11	25	44	68
(b) α = .05, β = .25					
.06 μ_c	30	120	269	478	748
.08 μ_c	17	67	151	269	421
.10 μ_c	11	43	97	192	269
.15 μ_c	5	19	43	77	120
.20 μ_c	3	11	24	43	67
.25 μ_c	2	7	16	28	43

[a] σ_e is the common standard deviation for both the treatment and control responses under the model and μ_c is the mean response (usage level) for the control. The sample size is calculated as $n = 2(CV/\Delta)^2(a_{1-\alpha} + a_{1-\beta})^2$ where z is the standard normal variate.

expenditures or risk perceptions is limited, this is even more difficult. Nevertheless, if the proportions are in the range of .35 to .40 or higher, then a reasonably precise estimate can be formed by requiring that $\delta = .20$ (i.e., $p\delta = (.35)(.20) = .07$ or $p\delta = (.40)(.20) = .08$). These values of p and δ produce a required sample size in the range of 144 to 178. The 2000+ sample for the NYSERDA sample, even divided into thirds for different information treatments, should be sufficient. Also, the comparison group sample of 250 completed interviews should offer sufficient precision. Of course, it would be useful to know the distribution of radon levels for the sample, but this information was not available until after the risk communication research design was set up. When those data are available, the final design was calibrated to ensure sufficient sample sizes. If necessary, the number of alternative treatments would have been reduced.

TABLE C-5. REQUIRED SAMPLE SIZE FOR THE ESTIMATES OF p TO BE WITHIN $p\delta$ UNITS OF p, ASSUMING SIMPLE RANDOM SAMPLING

	δ				
p	.05	.10	.15	.20	.25
.01	152,127	38,032	16,903	9,508	6,085
.05	29,196	7,299	3,244	1,825	1,168
.10	13,830	3,457	1,537	864	553
.25	4,610	1,152	512	288	184
.35	2,854	713	317	178	114
.40	2,305	576	256	144	92
.50	1,537	384	171	96	61
.75	512	129	57	33	21
.95	81	21	9	6	4

Appendix D

Questionnaires

Baseline Survey: Monitored Sample

Baseline Survey: Comparison Sample

Followup Survey: Monitored Sample
  NYSERDA Version
  EPA Version
  Fact Sheet Version

Followup Survey: Comparison Sample

OMB 2010-0014
Expires 5/88

Baseline Survey for New York Radon Information Study

Hello, my name is ___________. I'm calling from the Research Triangle Institute (RTI), in Research Triangle Park, North Carolina. We are conducting the radon study for the State of New York. May I please speak with:

Place label here	☐ Person unavailable. Call back time: ____________________ ☐ Respondent reschedules. Callback time: ____________________

IF NOT AVAILABLE, ASK PERSON ANSWERING:

Do you make or share in important decisions for this household?

01 Yes
02 No *(ASK WHEN TO CALL BACK TO REACH A DECISIONMAKER. RECORD CALLBACK TIME ABOVE.)*

___________, we would like to thank you for sending your radon monitor back to RTI. By mid-July, we will have the results from the 2-month readings for the people in the study. Because these are only preliminary results, it is important to leave the 12-month monitors in place until we notify you. Now I would like to ask you a few questions about what you know and think about radon. This should take only a few minutes and your answers will be kept strictly confidential. *(READ IF NECESSARY.* Your cooperation is especially important, because we have scientifically selected the households for this study.)

(IF RESPONDENT WANTS TO RESCHEDULE, ESTABLISH CALLBACK TIME AND RECORD ABOVE.)

Temporary Interview Code	Final Interview Code
01 Ring No Answer	15 Ring, No Answer
02 Regular Busy Signal	16 Nonworking Number
03 Answering Machine Service	17 Double Wrong Connection
04 No Result From Dial	18 Answering Machine/Service
05 Temporarily Nonworking	19 No Result From Dial
06 Wrong Number	20 Fast Busy/Computer Tone
07 Fast Busy/Computer Tone	21 Unable to Contact
08 Language Barrier	22 Physically/Mentally Incompetent
09 Partial Data	23 Language Barrier
10 Pending Interview Refusal	24 Trials Exhausted
11 Not Available/Callback Scheduled	25 Interview Completed
12 Not Available/Estimated Callback Scheduled	26 Partial Data
13 Physically/Mentally Incompetent	27 Final Interview Refusal
14 Other	28 Other

SECTION I: RADON KNOWLEDGE

I am going to ask some multiple choice questions about radon. Please choose the answer you think is correct or answer "I don't know" if that's your best answer.

	Record Responses
1. Is radon a	
a. Colorless, odorless gas	01
b. Or a chemical given off by radar equipment	02
c. Don't know *(DON'T READ)*	94
2. Is radon caused by	
a. Industrial pollution	01
b. Or the natural breakdown of uranium	02
c. Don't know *(DON'T READ)*	94
3. Are high levels of radon likely to cause	
a. Minor skin problems	01
b. Or lung cancer	02
c. Don't know *(DON'T READ)*	94
4. Does the amount of radon in a building depend mainly on the	
a. Type of machines or appliances in it	01
b. Or the amount of radon in the underlying soil	02
c. Don't know *(DON'T READ)*	94
5. Do the risks from radon exposure	
a. Increase the longer you are exposed	01
b. Or stay the same no matter how long you are exposed	02
c. Don't know *(DON'T READ)*	94
6. When radon is measured in a building, the level will	
a. Depend on the time of year it's measured	01
b. Not depend on the time of year it's measured	02
c. Don't know *(DON'T READ)*	94
7. Are radon levels usually higher in the	
a. Basement or lowest floor	01
b. Or the highest floor	02
c. Don't know *(DON'T READ)*	94
8. Will people's risk from radon exposure	
a. Increase if they smoke	01
b. Or stay about the same if they smoke	02
c. Don't know *(DON'T READ)*	94
9. Can the level of radon in a home or building be reduced by	
a. Increasing the amount of air ventilation	01
b. Or by adding attic insulation	02
c. Don't know *(DON'T READ)*	94
10. Are household appliances such as furnaces or clothes dryers likely to	
a. Increase the amount of radon by lowering inside air pressure	01
b. Or decrease the amount of radon by venting it outside	02
c. Don't know *(DON'T READ)*	94

	Record Responses
11. Would the effectiveness of ways to reduce radon in homes or buildings	
a. Be the same for all housing or building types	01
b. Or depend on the features of each home or building	02
c. Don't know *(DON'T READ)*	94
12. Will drawing radon away from the home or building before it enters	
a. Usually involve several thousand dollars and an experienced contractor	01
b. Or be done cheaply and quickly by almost anyone	02
c. Don't know *(DON'T READ)*	94

Now I'd like to ask you a few questions about any information you may have read or heard about radon.

13. During the past 3 months, have you read or heard anything in the news about radon?

01 Yes

02 No → *(GO TO Q.16)*

14. About how many times during the last 3 months have you read or heard anything in the news?

__________ *(RECORD NUMBER)*

15. Some people may have done more than others to find out about radon. Have you ever . . . *(READ LIST)*

	YES	NO	DON'T KNOW
a. Bought a newspaper or a magazine **specifically** to read something about radon?	01	02	94
b. Tuned into a television or a radio program **specifically** to learn about radon?	01	02	94
c. Obtained information from a library about radon?	01	02	94
d. Contacted a federal, state, or local government agency to get information about radon?	01	02	94
e. Attended a public or neighborhood meeting about radon?	01	02	94
f. Discussed radon with friends and relatives?	01	02	94
g. Done anything **else** that I haven't mentioned to obtain information about radon? *(IF YES, ASK:* **What was that?***) (RECORD ANSWERS BELOW)*	01	02	94

____

____

____

____

16. If you decided you wanted to know more about radon, which government agency would you be most likely to turn to for more radon information? *(DO NOT READ LIST. PROBE FOR SPECIFIC AGENCY IF RESPONDENT SAYS GOVERNMENT. CIRCLE YES OR NO FOR ANSWERS. RECORD OTHER RESPONSES IN BLANKS.)*

	YES	NO
NYSERDA (or people conducting this study)	01	02
State Health Department	01	02
Local Health Department	01	02
State Environmental Protection Agency	01	02
Federal Environmental Protection Agency	01	02
Other *(specify)* ______________________	01	
Other *(specify)* ______________________	01	
Don't know		94

17. There are many different ways to get information about radon. I'm going to read a list of ways the State might make radon information available to homeowners. Please tell me how likely you'd be to use the information sources I name.

	Very Likely	Likely	Unlikely	Very Unlikely	Don't Know
In a booklet mailed to your house	01	02	03	04	94
From a speaker at a neighborhood meeting	01	02	03	04	94
Presented by a panel of experts at a meeting in your city or town	01	02	03	04	94
Shown on a television special about radon	01	02	03	04	94
Made available on a videocassette that you could borrow from a local library	01	02	03	04	94

18. In your opinion, who or what is responsible for the high radon levels in some homes? *(DO NOT READ LIST. CIRCLE ANY THAT RESPONDENT MENTIONS.)*

a. No one is responsible	01
b. Builders	01
c. Industry	01
d. Federal government	01
e. State government	01
f. Local government	01
g. Homeowners	01
h. Nature	01
i. Utility company	01
j. Other *(specify)* ______________________	01
k. Don't know *(DON'T READ)*	94

19. Please tell me whether you agree or disagree with the following statements.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
a. Radon is a serious concern in the city or town you live in	01	02	03	04	94
b. Radon is a serious concern in your neighborhood	01	02	03	04	94
c. The concern about radon is greatly exaggerated	01	02	03	04	94

SECTION II: RADON RISK INFORMATION

20. Compared to other health risks people face, how serious a health risk is radon—on a scale from 1 to 10 with 1 being not at all serious and 10 being very serious. *(RECORD RESPONSE AND PROBE FOR RANGE OR NUMBER.)*

____

21. Now, I'd like you to think about risks you and your household face.

a. On that same 1 to 10 scale, how serious are risks you (and your household) face from auto accidents? __________

b. On that same 1 to 10 scale, how serious are risks you (and your household) face from home accidents? __________

c. On that same 1 to 10 scale, how serious are risks you (and your household) face from being exposed to hazardous wastes from factories or landfills? __________

d. On that same 1 to 10 scale, how serious are risks you (and your household) face from being exposed to radon? __________

22. I am going to ask you about different causes of death. It may help you to know that heart disease is the single highest cause of death, accounting for about 750,000 deaths per year. Floods cause about 150 deaths per year. Please tell me how many people you think will die during the next year from being exposed to radon—about

a. 10 or less 01
b. 100 02
c. 1,000 03
d. 10,000 04
e. 100,000 05
f. Don't know *(DON'T READ)* 94

(IF NECESSARY, REPEAT THE NUMBER OF DEATHS FROM HEART DISEASE AND FLOODS. ALSO, REPEAT CHOICES. IF RESPONDENT GIVES A SPECIFIC NUMBER, PLEASE ASK HIM FOR THE CHOICE HE THINKS IS CLOSEST.)

23. Please tell me if you agree or disagree with the following statements about radon compared to other risks.

	Strongly Agree	**Agree**	**Disagree**	**Strongly Disagree**	**Don't Know**
The risk of dying from radon is very similar to the risk of dying from floods	01	02	03	04	94
The risk of dying from radon is very similar to the risk of dying from auto accidents	01	02	03	04	94
The risk of dying from radon is very similar to the risk of dying from chemicals in abandoned hazardous waste sites	01	02	03	04	94
The risk of dying from radon is very similar to the risk of dying from a nuclear power plant accident	01	02	03	04	94
The risk of dying from radon is very similar to the risk of dying from leukemia	01	02	03	04	94

24. Please tell me if you agree or disagree with the following statements about radon.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
a. Radon is a new risk	01	02	03	04	94
b. Radon usually involves death	01	02	03	04	94
c. Radon usually involves sudden death	01	02	03	04	94
d. Radon could kill large numbers of people at one time	01	02	03	04	94
e. Most people who have radon in their homes can control it easily	01	02	03	04	94
f. Most people who have radon in their homes know it	01	02	03	04	94
g. Most people who have radon in their homes have learned to live with it	01	02	03	04	94

SECTION III: HOUSEHOLD AND DWELLING CHARACTERISTICS

Now, Mr./Ms. ________________, we're almost finished. I'm going to ask a few questions about yourself and your house.

25. Please tell me how well each of the following statements I read describes you.

	Very Well	Fairly Well	Somewhat	Not at All Well	Don't Know
a. You usually try to fix things around the house	01	02	03	04	94
b. You usually wait until you have a lot of information before you decide to buy something like a new appliance	01	02	03	04	94
c. You often question information from experts or other authorities	01	02	03	04	94
d. You often feel uncomfortable making decisions about complicated purchases like a heating system for your home	01	02	03	04	94
e. You are used to working with numbers or math because of your job or some other interests	01	02	03	04	94
f. You always ask your physician a lot of questions or regularly read articles about health	01	02	03	04	94
g. You exercise regularly or watch what you eat to protect your health	01	02	03	04	94
h. You wear your seatbelt every time you drive your car	01	02	03	04	94
i. You have bought more life insurance than you probably need	01	02	03	04	94

26. **During our last interview, we asked you several questions about your home such as type of furnace, windows, and the like. Since that interview, have you made any of the following major changes to your home? Have you:**

Changes	Yes	No	Don't Know	If Yes, record date and amount spent: Date (Record month number, e.g., 1 = Jan, 2 = Feb.)	If Yes, record date and amount spent: Amount Spent ($)
a. Changed your attic insulation	01	02	94	________	________
b. Caulked your windows or doors	01	02	94	________	________
c. Installed a new furnace or air-conditioning system	01	02	94	________	________
d. Changed your doors or windows	01	02	94	________	________
e. Sealed cracks in your basement	01	02	94	________	________
f. Changed how much time you or your family spend in the basement	01	02	94	________	________
g. Made any other major changes *(describe)* ________ ________	01	02	94	________	________
h. Other ________	01	02	94	________	________
i. Other ________	01	02	94	________	________

27. **How many years have your lived at this address?** ________ years

28. **How many people are in your household?** ________

29. **How many are children under 12?** ________

30. **What was the last grade of regular school that you completed—not counting specialized schools like secretarial, art, or trade schools?**

No school	01
Grade school (1-8)	02
Some high school (9-11)	03
High school graduate (12)	04
Some college (13-15)	05
College graduate	06
Postgraduate (17+)	07
Refused	97

Telephone No.

OMB 2010-0014
Expires 5/88

Radon Information Effectiveness Survey: Comparison Group Baseline Questionnaire

SECTION I: RADON KNOWLEDGE

I am going to ask some multiple choice questions about radon. Please choose the answer you think is correct or answer "I don't know" if that's your best answer.

	Record Responses
1. Is radon a	
a. Colorless, odorless gas	01
b. Or a chemical given off by radar equipment	02
c. Don't know *(DON'T READ)*	94
2. Is radon caused by	
a. Industrial pollution	01
b. Or the natural breakdown of uranium	02
c. Don't know *(DON'T READ)*	94
3. Are high levels of radon likely to cause	
a. Minor skin problems	01
b. Or lung cancer	02
c. Don't know *(DON'T READ)*	94
4. Does the amount of radon in a building depend mainly on the	
a. Type of machines or appliances in it	01
b. Or the amount of radon in the underlying soil	02
c. Don't know *(DON'T READ)*	94
5. Do the risks from radon exposure	
a. Increase the longer you are exposed	01
b. Or stay the same no matter how long you are exposed	02
c. Don't know *(DON'T READ)*	94
6. When radon is measured in a building, the level will	
a. Depend on the time of year it's measured	01
b. Not depend on the time of year it's measured	02
c. Don't know *(DON'T READ)*	94
7. Are radon levels usually higher in the	
a. Basement or lowest floor	01
b. Or the highest floor	02
c. Don't know *(DON'T READ)*	94
8. Will people's risk from radon exposure	
a. Increase if they smoke	01
b. Or stay about the same if they smoke	02
c. Don't know *(DON'T READ)*	94

	Record Responses
9. Can the level of radon in a home or building be reduced by	
a. Increasing the amount of air ventilation	01
b. Or by adding attic insulation	02
c. Don't know *(DON'T READ)*	94
10. Are household appliances such as furnaces or clothes dryers likely to	
a. Increase the amount of radon by lowering inside air pressure	01
b. Or decrease the amount of radon by venting it outside	02
c. Don't know *(DON'T READ)*	94
11. Would the effectiveness of ways to reduce radon in homes or buildings	
a. Be the same for all housing or building types	01
b. Or depend on the features of each home or building	02
c. Don't know *(DON'T READ)*	94
12. Will drawing radon away from the home or building before it enters	
a. Usually involve several thousand dollars and an experienced contractor	01
b. Or be done cheaply and quickly by almost anyone	02
c. Don't know *(DON'T READ)*	94

Now I'd like to ask you a few questions about any information you may have read or heard about radon.

13. During the past 3 months, have you read or heard anything in the news about radon?

01 Yes
02 No – *(GO TO Q.16)*

14. About how many times during the last 3 months have you read or heard anything in the news?

__________ *(RECORD NUMBER)*

15. Some people may have done more than others to find out about radon. Have you ever . . . *(READ LIST)*

	YES	NO	DON'T KNOW
a. Bought a newspaper or a magazine **specifically** to read something about radon?	01	02	94
b. Tuned into a television or a radio program **specifically** to learn about radon?	01	02	94
c. Obtained information from a library about radon?	01	02	94
d. Contacted a federal, state, or local government agency to get information about radon?	01	02	94
e. Attended a public or neighborhood meeting about radon?	01	02	94
f. Discussed radon with friends and relatives?	01	02	94
g. Done anything **else** that I haven't mentioned to obtain information about radon? *(IF YES, ASK:* **What was that?**) *(RECORD ANSWERS BELOW)*	01	02	94

____

____

16. If you decided you wanted to know more about radon, which government agency would you be most likely to turn to for more radon information? *(DO NOT READ LIST. PROBE FOR SPECIFIC AGENCY IF RESPONDENT SAYS GOVERNMENT. CIRCLE YES OR NO FOR ANSWERS. RECORD OTHER RESPONSES IN BLANKS.)*

	YES	NO
NYSERDA (or people conducting this study)	01	02
State Health Department	01	02
Local Health Department	01	02
State Environmental Protection Agency	01	02
Federal Environmental Protection Agency	01	02
Other *(specify)* ____________________	01	
Other *(specify)* ____________________	01	
Don't know		94

17. There are many different ways to get information about radon. I'm going to read a list of ways the State might make radon information available to homeowners. Please tell me how likely you'd be to use the information sources I name.

	Very Likely	Likely	Unlikely	Very Unlikely	Don't Know
In a booklet mailed to your house	01	02	03	04	94
From a speaker at a neighborhood meeting	01	02	03	04	94
Presented by a panel of experts at a meeting in your city or town	01	02	03	04	94
Shown on a television special about radon	01	02	03	04	94
Made available on a videocassette that you could borrow from a local library	01	02	03	04	94

18. In your opinion, who or what is responsible for the high radon levels in some homes? *(DO NOT READ LIST. CIRCLE ANY THAT RESPONDENT MENTIONS.)*

a. No one is responsible	01
b. Builders	02
c. Industry	03
d. Federal government	04
e. State government	05
f. Local government	06
g. Homeowners	07
h. Nature	08
i. Utility company	09
j. Other *(specify)* ____________	10
k. Don't know *(DON'T READ)*	94

19. Please tell me whether you agree or disagree with the following statements.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
a. Radon is a serious concern in the city or town you live in	01	02	03	04	94
b. Radon is a serious concern in your neighborhood	01	02	03	04	94
c. The concern about radon is greatly exaggerated	01	02	03	04	94

SECTION II: RADON RISK INFORMATION

20. Compared to other health risks people face, how serious a health risk is radon—on a scale from 1 to 10 with 1 being not at all serious and 10 being very serious. *(RECORD RESPONSE AND PROBE FOR RANGE OR NUMBER.)*

____

21. Now, I'd like you to think about risks you and your household face.

a. On that same 1 to 10 scale, how serious are risks you (and your household) face from auto accidents? __________

b. On that same 1 to 10 scale, how serious are risks you (and your household) face from home accidents? __________

c. On that same 1 to 10 scale, how serious are risks you (and your household) face from being exposed to hazardous wastes from factories or landfills? __________

d. On that same 1 to 10 scale, how serious are risks you (and your household) face from being exposed to radon? __________

22. I am going to ask you about different causes of death. It may help you to know that heart disease is the single highest cause of death, accounting for about 750,000 deaths per year. Floods cause about 150 deaths per year. Please tell me how many people you think will die during the next year from being exposed to radon—about

a. 10 or less	01
b. 100	02
c. 1,000	03
d. 10,000	04
e. 100,000	05
f. Don't know *(DON'T READ)*	94

(IF NECESSARY, REPEAT THE NUMBER OF DEATHS FROM HEART DISEASE AND FLOODS. ALSO, REPEAT CHOICES. IF RESPONDENT GIVES A SPECIFIC NUMBER, PLEASE ASK HIM FOR THE CHOICE HE THINKS IS CLOSEST.)

SECTION III: HOUSEHOLD AND DWELLING CHARACTERISTICS

Now, Mr./Ms. ________________, we're almost finished. I'm going to ask a few questions about yourself and your house.

23. Please tell me how well each of the following statements I read describes you.

	Very Well	Fairly Well	Somewhat	Not at All Well	Don't Know
a. You usually try to fix things around the house. Does that describe you	01	02	03	04	94
b. You usually wait until you have a lot of information before you decide to buy something like a new appliance. Does that describe you	01	02	03	04	94
c. You often question information from experts or other authorities. Does that describe you	01	02	03	04	94
d. You often feel uncomfortable making decisions about complicated purchases like a heating system for your home. Does that describe you	01	02	03	04	94
e. You are used to working with numbers or math because of your job or some other interests. Does that describe you	01	02	03	04	94
f. You always ask your physician a lot of questions or regularly read articles about health. Does that describe you	01	02	03	04	94
g. You exercise regularly or watch what you eat to protect your health. Does that describe you	01	02	03	04	94
h. You wear your seatbelt every time you drive your car. Does that describe you	01	02	03	04	94
i. You have bought more life insurance than you probably need. Does that describe you	01	02	03	04	94

24. How many years have your lived at this address? _______ years

25. Was your dwelling built:

Before 1940	01	
Between 1940 and 1976	02	
After 1976	03	
Don't know *(DON'T READ)*	94	→ *PROBE "Approximately"?*

26. Have you had your home tested for radon?

Yes	01	→ **When did you get your results?** ____________ month
No	02	

27. a. Do you have a full or partial basement?

Yes . . . . 01 — *CONTINUE*
No . . . . 02 — *SKIP TO Q.28*

b. Do you use any part of your basement as a living space such as a recreation room, family room, bedroom, etc.?

Yes 01
No 02

c. Is any part of your basement floor exposed earth?

Yes 01
No 02

28. In the past 6 months, have you made any of the following major changes to your home? Have you:

				If Yes, record date and amount spent	
Changes	**Yes**	**No**	**Don't Know**	**Date** *(Record month number, e.g., 1 = Jan.; 2 = Feb.)*	**Amount Spent ($)**
a. Changed your attic insulation . .	01	02	94	______	______
b. Caulked your windows or doors .	01	02	94	______	______
c. Installed a new furnace or air-conditioning system	01	02	94	______	______
d. Changed your doors or windows	01	02	94	______	______
e. Sealed cracks in your basement	01	02	94	______	______
f. Changed how much time you or your family spend in the basement	01	02	94	______	______
g. Made any other major changes *(describe)* ______ ______	01	02	94	______	______
h. Other ______	01	02	94	______	______
i. Other ______	01	02	94	______	______

29. How many people are in your household? ______

30. How many are children under 12? ______

31. How many people smoke tobacco? ______

32. What was the last grade of regular school that you completed—not counting specialized schools like secretarial, art, or trade schools?

No school 01
Grade school (1-8) 02
Some high school (9-11) 03
High school graduate (12) 04
Some college (13-15) 05
College graduate 06
Postgraduate (17+) 07
Refused 97

33. What is your occupation? *(CIRCLE APPROPRIATE CATEGORY.)*

a. Professional or technical (accountant, engineer, lawyer, teacher, technician, writer, designer)	01
b. Farmer	02
c. Managerial (official, proprietor, administrator, buyer, superintendent)	03
d. Clerical (teller, clerk, adjuster, receptionist, secretary, bookkeeper)	04
e. Sales worker (stockbroker, sales clerk, insurance, advertising)	05
f. Craftsman (foreman, electrician, dental technician, mechanic, plumber)	06
g. Operative (butcher, machine operator, seamstress, assembler)	07
h. Transport operative (busdriver, truckdriver, cabbie)	08
i. Service worker (maid, butler, dental assistant, waiter, nurse's aid, hairdresser, policeman, fireman)	09
j. Laborer (garbage collector, construction worker, longshoreman)	10
k. Retired	11
l. Student	12
m. Unemployed	13
n. Housewife	14
o. Other *(specify)* ______________________	15
p. Don't know *(DON'T READ)*	94

34. What is your age? __________

35. Is your racial or ethnic background

White or Caucasian	01	Asian or Pacific Islander	04
Black or Negro	02	Native American Indian	05
Hispanic	03		

36. *(PLEASE INDICATE SEX OF THE RESPONDENT)*

Male	01
Female	02

37. What is the market value of your home? $______________. *PROBE for approximate dollar amounts.*

38. I am going to read some income categories for family income from all sources before taxes during 1985. Please tell me to stop when I get to yours.

$5,000 or under	01	$50,001 - $65,000	06
$5,001 - $15,000	02	$65,001 - $80,000	07
$15,001 - $25,000	03	$80,001 and over	09
$25,001 - $35,000	04	Don't know *(DON'T READ)*	94
$35,001 - $50,000	05	Refused	97

May I have your name, please? ____

TERMINATION

Thank you very much for your cooperation. Your answers will be most helpful in this study.

CONTROL FORM FOR THE NEW YORK RADON FOLLOW-UP SURVEY

INTERVIEW START TIME: ________________ STOP TIME: ____________ NYSERDA

AFFIX ASSIGNMENT
LABEL HERE

Remail: Booklets ______ Letter _____ Date __________

RECORD OF TELEPHONE CONTACTS

DAY OF WEEK	DATE	TIME	NOTES	RESULT CODE	TI INITIALS
		A P			
		A P			
		A P			
		A P			
		A P			
		A P			
		A P			
		A P			
		A P			
		A P			

CONTACT RESULT CODES

01 Interview Complete
02 Interview breakoff/partial data
03 Interview Refusal
04 Call back; respondent has not read the materials
05 Call back; respondent unavailable
06 Call back; ring, no answer or busy signal
07 Call back; remail materials
08 Unlisted number
09 Not a working or residential number

SECTION I: INTRODUCTION

Hello, my name is ______________________. I'm calling from Research Triangle Institute in North Carolina. We are conducting the follow-up survey of participants in the State of New York's radon study. I would like to talk with (READ NAME ON THE ASSIGNMENT LABEL), or the person we spoke with early last summer about the radon study.

WHEN YOU ARE TALKING WITH THE PERSON WHO WAS PREVIOUSLY INTERVIEWED, RECORD THAT PERSON'S NAME BELOW.

Respondent's Name: ______________________________

Q.1 Did you recently receive radon information booklet(s) and a letter containing the radon reading for your home? CIRCLE A "YES" OR "NO" RESPONSE FOR EACH ITEM.

	Radon Booklet(s)	Radon Reading	
Yes	01	01	If both are "Yes", go to Statement 2 below
No	02	02	If either is "No", go to Statement 1 below

STATEMENT 1

There must have been a mailing error. I will notify the project leader and have the missing material mailed out to you tomorrow. I'll call again after you've had time to get the materials and read them. I want to confirm your name and mailing address.

CONFIRM THE PERSON'S NAME AND MAILING ADDRESS. MAKE NECESSARY CORRECTIONS ON THE ASSIGNMENT LABEL. CHECK WHICH ITEM, BOOKLET OR LETTER, IS TO BE REMAILED. RETURN THIS CASE TO CEER STAFF.

STATEMENT 2

I'd like to ask some questions about the radon materials. This should take only a few minutes and your answers will be kept strictly confidential.

Q.2 Did you read the radon information booklet(s)?

Yes 01 → Go to Section 2

No 02 → Go to Statement 3

STATEMENT 3

Since many of my questions are about the information in the booklet(s), I need to ask the questions after you have had a chance to read them. Would this time tomorrow be a good time to call back?

PROBE FOR A CONVENIENT CALLBACK TIME AND RECORD THE TIME IN THE NOTES SECTION ON THE CONTROL PAGE. IF THE RESPONDENT DECLINES TO BE INTERVIEWED, ASK IF ANOTHER ADULT MEMBER OF THE HOUSEHOLD HAS READ THE MATERIALS. ATTEMPT TO INTERVIEW THAT PERSON DURING THIS CALL.

Yes	01	Record callback time
Refused	02	Terminate interview
New Respondent Named	03	Record name of new respondent and attempt to interview

SECTION II: MATERIALS RECEIPT INFORMATION

RECORD THE DATE OF THE INTERVIEW: ___________/__________

Q.4 When did you receive the letter with the radon reading? When did you receive the radon booklet(s)? PROBE FOR APPROXIMATE DATES. USE NUMBERS FOR MONTH. IF RESPONSE IS "LAST WEEK," ASK ABOUT HOW MANY DAYS AGO THE MATERIALS WERE RECEIVED.

	Letter With Radon Reading	Radon Booklet(s)
Date	______/______	______/_____
Don't know	94	94

Q.5 When did you last read the materials? PROBE FOR APPROXIMATE DATE.

Date ______/______

Don't know 94

Q.6 Altogether, about how long did you spend reading the materials? PROBE FOR APPROXIMATE TIME. RECORD TIME IN MINUTES.

Minutes ____________

Don't know 94

SECTION III: RADON INFORMATION BOOKLET EVALUATION

Q.7 The first few questions are about your opinions of the radon booklet with the white cover. MAKE SURE THE RESPONDENT KNOWS WHICH BOOKLET YOU ARE REFERRING TO.

For each statement I read, please tell me how strongly you agree or disagree with it.

	Strongly Agree	Agree	Dis-agree	Strongly Disagree	Don't Know
a. The booklet was written in everyday English	01	02	03	04	94
b. The booklet was easy to follow	01	02	03	04	94
c. The booklet covered what you needed to know	01	02	03	04	94
d. The booklet made it easy for you to evaluate your risk	01	02	03	04	94
e. The booklet information was consistent with what you had already read about radon	01	02	03	04	94

Q.8 The booklet explained radon risk as the risk of dying from exposure to radon over a lifetime. For each statement I read, tell me how strongly you agree or disagree with it.

	Strongly Agree	Agree	Dis-agree	Strongly Disagree	Don't Know
a. Explaining radon risk as a lifetime risk makes it easy to understand your radon risk	01	02	03	04	94
b. Explaining radon risk as a lifetime risk makes it easy to decide whether to reduce radon levels in your home soon	01	02	03	04	94
c. Explaining radon risk as a lifetime risk makes it easy to compare radon with other health risks	01	02	03	04	94

Q.9 For the next question, I'd like you to think about whether features of the main radon risk chart in the middle of the white booklet helped or did not help you understand your radon risk. For each feature I read, tell me if it helped, did not help, or confused you.

	Helped	No Help	Confused	Don't Know
a. Numbers on the chart	01	02	03	94
b. Comparison of radon risk with smoking	01	02	03	94
c. Comparison of radon risk with x-rays	01	02	03	94
d. Comparison of radon risk with an occupational risk	01	02	03	94
e. Colors on the chart	01	02	03	94

Q.10 Was there anything else about the chart that you found to be particularly helpful or confusing?

Helpful: ____

Helpful ____

Confusing: ____

Confusing: ____

Q.11 Which color on the radon risk chart did your radon reading correspond to? DON'T READ THE LIST

GREEN	01
YELLOW	02
ORANGE	03
RED	04
OTHER ________	05
DON'T RECALL	94

SECTION IV: RISK ADJUSTMENT

Q.12 The lifetime risk of dying was calculated for a typical household. Did you think that your risk or your household's risk was typical, or did you adjust the typical lifetime risk for your household's circumstances? DO NOT READ THE LIST

ADJUSTED LIFETIME RISK	01 → Go to Q.14
USED LIFETIME RISK	02 → Go to Q.13
NEITHER USED NOR ADJUSTED THE RISK	03 → Go to Q.13

Q.13 People have different reasons for not making an adjustment. Was there a particular reason why you did not adjust the risk to fit your own circumstances? DON'T READ THE LIST.

a.	BOOKLET TOLD ME TO USE THE LIFETIME RISK	01	
b.	YOUR TYPICAL LIFETIME RISK WAS SO LOW THAT YOU DIDN'T NEED TO MAKE AN ADJUSTMENT	02	
c.	YOU WERE NOT SURE HOW TO MAKE AN ADJUSTMENT	03	FOR ANY RESPONSE GO TO Q.16
d.	THE TYPICAL LIFETIME RISK FITS YOUR PRESENT CIRCUMSTANCES	04	
e.	DIDN'T THINK ABOUT DOING IT	05	
f.	OTHER REASON (SPECIFY) ____________________ ________________________________	06	
g.	DON'T KNOW	94	

Q.14 Did you adjust the risk for yourself, another adult, children, or for the household as a whole? CHECK WHO THE ADJUSTMENTS WERE MADE FOR. THEN ASK....

Compared to the typical lifetime risk, was the adjusted risk for (you, the other adult, the children, the household) (READ ITEMS a. THROUGH e. BELOW). REPEAT LIST FOR EACH PERSON ADJUSTMENT WAS MADE FOR.

		Respondent	Adult	Children	Household
		________	____	________	________
a.	Much lower	01	01	01	01
b.	Lower	02	02	02	02
c.	About the same as	03	03	03	03
d.	Higher	04	04	04	04
e.	Much higher	05	05	05	05
f.	DON'T KNOW (DON'T READ)	94	94	94	94

Q.15 For each factor I read, tell me if you considered it in adjusting the typical lifetime risk for (yourself, the other adult, the children, the household). READ ITEMS a. THROUGH f. BELOW FOR EACH PERSON THE ADJUSTMENT WAS MADE FOR. CIRCLE THE APPROPRIATE NUMBER TO INDICATE WHICH FACTOR WAS CONSIDERED.

	Respondent	Adult	Children	Household
a. Age	01	01	01	01
b. The length of time lived in your present home	02	02	02	02
c. How many hours spent at home each day	03	03	03	03
d. Present health	04	04	04	04
e. Smoking habits	05	05	05	05
f. How much time spent in certain parts of the house - for example, in the basement	06	06	06	06

SECTION V: RISK MITIGATION

Q.16 Since receiving your radon reading, have you or anyone in your household done anything, made any plans to do anything, or considered doing anything to reduce your household's exposure to radon?

Yes	01	→ Go to Q.17
No	02	→ Go to Q.18
Don't know	94	→ Go to Q.18

Q.17 Please tell me what has been done, planned, or considered? DON'T READ ITEMS a. THROUGH q. IF ACTION INVOLVES A TECHNICAL CHANGE OR EQUIPMENT, PROBE FOR ESTIMATED COST.

BEHAVIORAL CHANGES	Done	Planned	Considered
a. EITHER STOP OR CUT DOWN ON SMOKING INSIDE THE HOME	01	02	03
b. REDUCE THE AMOUNT OF TIME SPENT IN CERTAIN AREAS OF YOUR HOME - FOR EXAMPLE, IN THE BASEMENT	01	02	03
c. OPEN WINDOWS AND TURN ON FANS TO INCREASE AIR FLOW INTO AND THROUGH THE HOUSE	01	02	03
d. ARRANGE FOR MORE RADON TESTS	01	02	03
e. CONTACT A CONTRACTOR	01	02	03
f. OPEN THE CRAWL-SPACE VENTS ON ALL SIDES OF THE HOUSE	01	02	03
g. REVIEW THE MATERIALS AGAIN AND THEN DECIDE WHAT TO DO	01	02	03
h. OTHER (SPECIFY) ______________________	01	02	03

TECHNICAL OR EQUIPMENT CHANGES	Done	Planned	Considered	Cost
i. INSTALL NATURAL VENTILATION	01	02	03	$________
j. INSTALL FORCED VENTILATION	01	02	03	$________
k. HEAT RECOVERY VENTILATION	01	02	03	$________
l. COVER EXPOSED EARTH	01	02	03	$________
m. SEAL CRACKS AND SPACES	01	02	03	$________
n. INSTALL DRAIN TILE (PIPE) SUCTION	01	02	03	$________
o. INSTALL BLOCK-WALL VENTILATION	01	02	03	$________
p. INSTALL SUB-SLAB SUCTION	01	02	03	$________
q. OTHER (SPECIFY) ______________________	01	02	03	$________

Q.18 Since we talked with you last summer, have you made any of the following major changes to your home? Have you (READ ITEMS a. THROUGH g.). ASK FOR THE APPROXIMATE MONTH EACH CHANGE WAS MADE, AND THE APPROXIMATE COST)

	Yes	No	Don't Know	Month	Cost
a. Changed your attic insulation	01	02	94	______	$______
b. Caulked your windows or doors	01	02	94	______	$______
c. Installed a new furnace or air conditioning system	01	02	94	______	$______
d. Changed your doors or windows	01	02	94	______	$______
e. Sealed cracks in your basement	01	02	94	______	$______
f. Installed an air-to-air heat exchanger	01	02	94	______	$______
g. Made any other changes (describe) ______________________________ ______________________________	01	02	94	______	$______

SECTION VI: EVALUATION OF RADON REDUCTION METHODS BOOKLET

Q.19 You were also sent a copy of a booklet with a blue cover called "Radon Reduction Methods." For each statement I read about this booklet, tell me how strongly you agree or disagree with it.

	Strongly Agree	Agree	Dis- agree	Strongly Disagree	Don't Know
a. The booklet was written in everyday English	01	02	03	04	94
b. The booklet was easy to follow	01	02	03	04	94
c. The booklet covered what you needed to know	01	02	03	04	94
d. The booklet information was easy to apply to your circumstances	01	02	03	04	94
e. The booklet gave enough information for you to make your own evaluation	01	02	03	04	94
f. The booklet information was consistent with what you had already read about radon	01	02	03	04	94

SECTION VII: RADON INFORMATION ACQUISITION AND DISCUSSION

Q.20 Have you discussed your radon reading or the booklets with anyone else?

Yes	01 →	Go to Q.21
No	02 →	Go to Q.22

Q.21 Who did you discuss radon with? DON'T READ THE ITEMS. CIRCLE ALL THAT APPLY. PROBE BY ASKING WAS THERE ANYONE ELSE.

a.	OTHER ADULT MEMBER OF THE HOUSEHOLD	01
b.	CHILDREN	02
c.	RELATIVES OUTSIDE YOUR HOME	03
d.	NEIGHBORS	04
e.	FRIENDS	05
f.	PEOPLE AT WORK	06
g.	CONTRACTORS	07
h.	PUBLIC OFFICIALS	08
i.	STATE AGENCIES	09
j.	FEDERAL AGENCIES	10
k.	TOLL FREE TELEPHONE NUMBER IN THE BROCHURE (NYSERDA OR PROJECT STAFF)	11
l.	OTHER (SPECIFY) ____________________	12
m.	OTHER (SPECIFY) ____________________	13

Q.22 Other than the materials that we sent, have you read or heard anything, or inquired about about radon since we talked with you last summer?

Yes	01 →	Go to Q.23
No	02 →	Go to Q.24
Don't know	94 →	Go to Q.24

Q.23 What was the source of that information? DON'T READ THE ITEMS. PROBE FOR ADDITIONAL SOURCES.

FOR EACH SOURCE MENTIONED, ASK IF WHAT WAS READ OR HEARD WAS BEFORE OR AFTER RECEIVING THE MATERIALS. UNDER THE APPROPRIATE COLUMN, CIRCLE ALL SOURCES THAT APPLY.

		Before	After
a.	READ ONE OF THE SOURCES LISTED IN THE BOOKLET	01	02
b.	READ A MAGAZINE OR NEWSPAPER ARTICLE	01	02
c.	HEARD A TV REPORT ABOUT RADON	01	02
d.	HEARD A RADIO REPORT ABOUT RADON	01	02
e.	ATTENDED A PUBLIC OR NEIGHBORHOOD MEETING	01	02
f.	ASKED A FRIEND OR NEIGHBOR	01	02
g.	ASKED YOUR FAMILY DOCTOR ABOUT RADON	01	02
h.	ASKED UNIVERSITY OR COLLEGE STAFF	01	02
i.	ASKED A GOVERNMENT AGENCY (SPECIFY AGENCY) ______________________	01	02
j.	ASKED A PUBLIC OFFICIAL (SPECIFY WHO) ______________________	01	02
k.	OTHER SOURCE (SPECIFY) ______________________	01	02
l.	NONE OF THE ABOVE	01	02

Q.24 I am going to read a list of ways the State might provide radon information to residents. Tell me if you would be very likely, likely, unlikely, or very unlikely to want information from each of these ways?

	Very Likely	Likely	Un-likely	Very Unlikely	Don't Know
a. A longer booklet containing more detailed information about radon risk	01	02	03	04	94
b. A longer booklet containing more detailed information about how to reduce radon levels	01	02	03	04	94
c. A panel of experts at a city or town meeting	01	02	03	04	94
d. A phone call from a state agency	01	02	03	04	94

Q.25 Suppose a qualified and state licensed person in your area would diagnose how radon was getting into your home. He would also help you decide what to do about it and where to find a qualified contractor. If the full cost of this service was (READ CIRCLED VALUE) $25 $50 $100 $150 $250 $400, would you purchase the service?

Yes	01
No	02
Don't know	94

SECTION VIII: NEW INFORMATION

Q.26 Now, I'd like to ask you about advising a family in your neighborhood on whether to reduce radon levels in their home. Suppose your neighbors were told that their reading for the winter months was (READ CIRCLED NUMBER) 3 4 5 8 10 15 20 30 50 75 picocuries per liter. Would you advise them to reduce their radon levels?

Yes	01 →	Go to Q.27
No	02 →	Go to Q.28
Don't know	94 →	Go to Q.28

Q.27 How soon would you advise them to reduce the levels? READ ITEMS a. THROUGH e.

a.	As soon as possible	01
b.	Within several weeks	02
c.	Within several months	03
d.	Within the next year	04
e.	Within the next few years	05
f.	DON'T KNOW (DON'T READ)	94

SECTION IX: BASELINE QUESTIONS

Q.28 Now, I'd like you to think about different risks you and your household face. For each type of risk that I read, please tell me how serious you think the risk is on a scale from 1 to 10. The number 1 on the scale is not at all serious and 10 is very serious.

Scale No.

a. On a 1 to 10 scale, how serious are risks you (and your household) face from auto accidents? ________

b. On that same 1 to 10 scale, how serious are risks you (and your household) face from home accidents? ________

c. On that same 1 to 10 scale, how serious are risks you (and your household) face from being exposed to hazardous wastes from factories or landfills? ________

d. On that same 1 to 10 scale, how serious are risks you (and your household) face from being exposed to radon? ________

Q.29 In general, compared to other health risks people face, how serious a health risk is radon? Use the same 1 to 10 scale. CIRCLE RESPONSE.

1 2 3 4 5 6 7 8 9 10 94

Q.30 Please tell me how strongly you agree or disagree with the following statements about radon risk compared to other types of risk.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
a. The risk of dying from radon is very similar to the risk of dying from floods	01	02	03	04	94
b. The risk of dying from radon is very similar to the risk of dying from chemicals in abandoned hazardous waste sites	01	02	03	04	94
c. The risk of dying from radon is very similar to the risk of dying from a nuclear power plant accident	01	02	03	04	94

Q.31 Are high levels of radon likely to cause (READ LIST)

a. Minor skin problems	01
b. Or lung cancer	02
c. DON'T KNOW (DON'T READ)	94

Q.32 High levels of radon exposure (READ LIST)

a. will irritate the throat and eyes	01
b. or will not irritate the throat and eyes	02
c. DON'T KNOW (DON'T READ)	94

Q.33 When radon is measured indoors, the level (READ LIST)

a. Will depend on whether the house is closed up 01

b. Or will not depend on whether the house is closed up 02

c. DON'T KNOW (DON'T READ) 94

Q.34 Are radon levels usually higher (READ LIST)

a. In the basement or lowest floor 01

b. Or on the highest floor 02

c. DON'T KNOW (DON'T READ) 94

Q.35 Are people's risk from one year of radon exposure (READ LIST)

a. Much lower than their risk from a lifetime exposure 01

b. Or about the same as their risk from a lifetime exposure 02

c. DON'T KNOW (DON'T READ) 94

Q.36 Are household appliances such as furnaces or clothes dryers likely to (READ LIST)

a. Increase the amount of radon by lowering inside air pressure 01

b. Or decrease the amount of radon by venting it outside 02

c. DON'T KNOW (DON'T READ) 94

Q.37 Do you still have questions or concerns about radon? If so, what are they?

____

____

____

THAT'S ALL OF THE QUESTIONS I HAVE. THANK YOU FOR YOUR COOPERATION.

CONTROL FORM FOR THE NEW YORK RADON FOLLOW-UP SURVEY

INTERVIEW START TIME: ________________ STOP TIME: ____________ EPA

AFFIX ASSIGNMENT
LABEL HERE

Remail: Booklets ______ Letter _____ Date __________

RECORD OF TELEPHONE CONTACTS

DAY OF WEEK	DATE	TIME	NOTES	RESULT CODE	TI INITIALS
		A P			
		A P			
		A P			
		A P			
		A P			
		A P			
		A P			
		A P			
		A P			
		A P			

CONTACT RESULT CODES

01 Interview Complete
02 Interview breakoff/partial data
03 Interview Refusal
04 Call back; respondent has not read the materials
05 Call back; respondent unavailable
06 Call back; ring, no answer or busy signal
07 Call back; remail materials
08 Unlisted number
09 Not a working or residential number

SECTION I: INTRODUCTION

Hello, my name is ______________________. I'm calling from Research Triangle Institute in North Carolina. We are conducting the follow-up survey of participants in the State of New York's radon study. I would like to talk with (READ NAME ON THE ASSIGNMENT LABEL), or the person we spoke with early last summer about the radon study.

WHEN YOU ARE TALKING WITH THE PERSON WHO WAS PREVIOUSLY INTERVIEWED, RECORD THAT PERSON'S NAME BELOW.

Respondent's Name: ________________________________

Q.1 Did you recently receive radon information booklet(s) and a letter containing the radon reading for your home? CIRCLE A "YES" OR "NO" RESPONSE FOR EACH ITEM.

	Radon Booklet(s)	Radon Reading	
Yes	01	01	If both are "Yes", go to Statement 2 below
No	02	02	If either is "No", go to Statement 1 below

STATEMENT 1

There must have been a mailing error. I will notify the project leader and have the missing material mailed out to you tomorrow. I'll call again after you've had time to get the materials and read them. I want to confirm your name and mailing address.

CONFIRM THE PERSON'S NAME AND MAILING ADDRESS. MAKE NECESSARY CORRECTIONS ON THE ASSIGNMENT LABEL. CHECK WHICH ITEM, BOOKLET OR LETTER, IS TO BE REMAILED. RETURN THIS CASE TO CEER STAFF.

STATEMENT 2

I'd like to ask some questions about the radon materials. This should take only a few minutes and your answers will be kept strictly confidential.

Q.2 Did you read the radon information booklet(s)?

Yes 01 → Go to Section 2

No 02 → Go to Statement 3

STATEMENT 3

Since many of my questions are about the information in the booklet(s), I need to ask the questions after you have had a chance to read them. Would this time tomorrow be a good time to call back?

PROBE FOR A CONVENIENT CALLBACK TIME AND RECORD THE TIME IN THE NOTES SECTION ON THE CONTROL PAGE. IF THE RESPONDENT DECLINES TO BE INTERVIEWED, ASK IF ANOTHER ADULT MEMBER OF THE HOUSEHOLD HAS READ THE MATERIALS. ATTEMPT TO INTERVIEW THAT PERSON DURING THIS CALL.

Yes	01	Record callback time
Refused	02	Terminate interview
New Respondent Named	03	Record name of new respondent and attempt to interview

SECTION II: MATERIALS RECEIPT INFORMATION

RECORD THE DATE OF THE INTERVIEW: ________/________

Q.4 When did you receive the letter with the radon reading? When did you receive the radon booklet(s)? PROBE FOR APPROXIMATE DATES. USE NUMBERS FOR MONTH. IF RESPONSE IS "LAST WEEK," ASK ABOUT HOW MANY DAYS AGO THE MATERIALS WERE RECEIVED.

	Letter With Radon Reading	Radon Booklet(s)
Date	_____/_____	_____/_____
Don't know	94	94

Q.5 When did you last read the materials? PROBE FOR APPROXIMATE DATE.

Date _____/_____

Don't know 94

Q.6 Altogether, about how long did you spend reading the materials? PROBE FOR APPROXIMATE TIME. RECORD TIME IN MINUTES.

Minutes __________

Don't know 94

SECTION III: RADON INFORMATION BOOKLET EVALUATION

Q.7 The first few questions are about your opinions of the radon booklet with the white cover. MAKE SURE THE RESPONDENT KNOWS WHICH BOOKLET YOU ARE REFERRING TO.

For each statement I read, please tell me how strongly you agree or disagree with it.

	Strongly Agree	Agree	Dis-agree	Strongly Disagree	Don't Know
a. The booklet was written in everyday English	01	02	03	04	94
b. The booklet was easy to follow	01	02	03	04	94
c. The booklet covered what you needed to know	01	02	03	04	94
d. The booklet made it easy for you to evaluate your risk	01	02	03	04	94
f. The booklet information was consistent with what you had already read about radon	01	02	03	04	94

Q.8 The booklet explained radon risk as the risk of dying from exposure to radon over a lifetime. For each statement I read, tell me how strongly you agree or disagree with it.

	Strongly Agree	Agree	Dis- agree	Strongly Disagree	Don't Know
a. Explaining radon risk as a lifetime risk makes it easy to understand your radon risk	01	02	03	04	94
b. Explaining radon risk as a lifetime risk makes it easy to decide whether to reduce radon levels in your home soon	01	02	03	04	94
c. Explaining radon risk as a lifetime risk makes it easy to compare radon with other health risks	01	02	03	04	94

Q.9 For the next question, I'd like you to think about whether features of the radon risk charts in the white booklet helped or did not help you understand your radon risk. For each feature I read, tell me if it helped, did not help, or confused you.

	Helped	No Help	Confused	Don't Know
a. Use of heads on the chart	01	02	03	94
b. Numbers on the chart	01	02	03	94
c. Comparison of radon risk with smoking	01	02	03	94
d. Comparison of radon risk with x-rays	01	02	03	94

Q.10 Was there anything else about the chart that you found to be particularly helpful or confusing?

Helpful:____

Helpful ____

Confusing:_______________________________________

Confusing: ______________________________________

Q.11 Do you recall where on the radon risk chart your reading was? Was it (READ ITEMS a. THROUGH d.)

a. Above the middle	01
b. In the middle	02
c. Below the middle	03
d. At the bottom	04
e. DON'T KNOW (DON'T READ)	94

SECTION IV: RISK ADJUSTMENT

Q.12 The lifetime risk of dying was calculated for a typical household. Did you think that your risk or your household's risk was typical, or did you adjust the typical lifetime risk for your household's circumstances? DO NOT READ THE LIST

ADJUSTED LIFETIME RISK	01 → Go to Q.14
USED LIFETIME RISK	02 → Go to Q.13
NEITHER USED NOR ADJUSTED THE RISK	03 → Go to Q.13

Q.13 People have different reasons for not making an adjustment. Was there a particular reason why you did not adjust the risk to fit your own circumstances? DON'T READ ITEMS a. THROUGH g.

a.	BOOKLET TOLD ME TO USE THE LIFETIME RISK	01	
b.	YOUR TYPICAL LIFETIME RISK WAS SO LOW THAT YOU DIDN'T NEED TO MAKE AN ADJUSTMENT	02	
c.	YOU WERE NOT SURE HOW TO MAKE AN ADJUSTMENT	03	
d.	THE TYPICAL LIFETIME RISK FITS YOUR PRESENT CIRCUMSTANCES	04	FOR ANY RESPONSE GO TO Q.16
e.	DIDN'T THINK ABOUT DOING IT	05	
f.	OTHER REASON (SPECIFY) ______________________ ______________________	06	
g.	DON'T KNOW	94	

Q.14 Did you adjust the risk for yourself, another adult, children, or for the household as a whole? CHECK WHO THE ADJUSTMENTS WERE MADE FOR. THEN ASK....

Compared to the typical lifetime risk, was the adjusted risk for (you, the other adult, the children, the household) (READ ITEMS a. THROUGH e. BELOW). REPEAT LIST FOR EACH PERSON ADJUSTMENT WAS MADE FOR.

		Respondent	Adult	Children	Household
		________	____	_______	________
a.	Much lower	01	01	01	01
b.	Lower	02	02	02	02
c.	About the same as	03	03	03	03
d.	Higher	04	04	04	04
e.	Much higher	05	05	05	05
f.	DON'T KNOW (DON'T READ)	94	94	94	94

Q.15 For each factor I read, tell me if you considered it in adjusting the typical lifetime risk for (yourself, the other adult, the children, the household). READ ITEMS a. THROUGH f. BELOW FOR EACH PERSON THE ADJUSTMENT WAS MADE FOR. CIRCLE THE APPROPRIATE NUMBER TO INDICATE WHICH FACTOR WAS CONSIDERED.

	Respondent	Adult	Children	Household
a. Age	01	01	01	01
b. The length of time lived in your present home	02	02	02	02
c. How many hours spent at home each day	03	03	03	03
d. Present health	04	04	04	04
e. Smoking habits	05	05	05	05
f. How much time spent in certain parts of the house - for example, in the basement	06	06	06	06

SECTION V: RISK MITIGATION

Q.16 Since receiving your radon reading, have you or anyone in your household done anything, made any plans to do anything, or considered doing anything to reduce your household's exposure to radon?

Yes	01	→ Go to Q.17
No	02	→ Go to Q.18
Don't know	94	→ Go to Q.18

Q.17 Please tell me what has been done, planned, or considered? DON'T READ ITEMS a. THROUGH q. IF ACTION INVOLVES A TECHNICAL CHANGE OR EQUIPMENT, PROBE FOR ESTIMATED COST.

BEHAVIORAL CHANGES

	Done	Planned	Considered
a. EITHER STOP OR CUT DOWN ON SMOKING INSIDE THE HOME	01	02	03
b. REDUCE THE AMOUNT OF TIME SPENT IN CERTAIN AREAS OF YOUR HOME - FOR EXAMPLE, IN THE BASEMENT	01	02	03
c. OPEN WINDOWS AND TURN ON FANS TO INCREASE AIR FLOW INTO AND THROUGH THE HOUSE	01	02	03
d. ARRANGE FOR MORE RADON TESTS	01	02	03
e. CONTACT A CONTRACTOR	01	02	03
f. OPEN THE CRAWL-SPACE VENTS ON ALL SIDES OF THE HOUSE	01	02	03
g. REVIEW THE MATERIALS AGAIN AND THEN DECIDE WHAT TO DO	01	02	03
h. OTHER (SPECIFY) ____________	01	02	03

TECHNICAL OR EQUIPMENT CHANGES

	Done	Planned	Considered	Cost
i. INSTALL NATURAL VENTILATION	01	02	03	$______
j. INSTALL FORCED VENTILATION	01	02	03	$______
k. HEAT RECOVERY VENTILATION	01	02	03	$______
l. COVER EXPOSED EARTH	01	02	03	$______
m. SEAL CRACKS AND SPACES	01	02	03	$______
n. INSTALL DRAIN TILE (PIPE) SUCTION	01	02	03	$______
o. INSTALL BLOCK-WALL VENTILATION	01	02	03	$______
p. INSTALL SUB-SLAB SUCTION	01	02	03	$______
q. OTHER (SPECIFY) ____________	01	02	03	$______

Q.18 Since we talked with you last summer, have you made any of the following major changes to your home? Have you (READ ITEMS a. THROUGH g.). ASK FOR THE APPROXIMATE MONTH EACH CHANGE WAS MADE, AND THE APPROXIMATE COST).

		Yes	No	Don't Know	Month	Cost
a.	Changed your attic insulation	01	02	94	_____	$_____
b.	Caulked your windows or doors	01	02	94	_____	$_____
c.	Installed a new furnace or air conditioning system	01	02	94	_____	$_____
d.	Changed your doors or windows	01	02	94	_____	$_____
e.	Sealed cracks in your basement	01	02	94	_____	$_____
f.	Installed an air-to-air heat exchanger	01	02	94	_____	$_____
g.	Made any other changes (describe)	01	02	94	_____	$_____

____

____

SECTION VI: EVALUATION OF RADON REDUCTION METHODS BOOKLET

Q.19 You were also sent a copy of a booklet with a blue cover called "Radon Reduction Methods." For each statement I read about this booklet, tell me how strongly you agree or disagree with it.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
a. The booklet was written in everyday English	01	02	03	04	94
b. The booklet was easy to follow	01	02	03	04	94
c. The booklet covered what you needed to know	01	02	03	04	94
d. The booklet information was easy to apply to your circumstances	01	02	03	04	94
e. The booklet gave enough information for you to make your own evaluation	01	02	03	04	94
f. The booklet information was consistent with what you had already read about radon	01	02	03	04	94

SECTION VII: RADON INFORMATION ACQUISITION AND DISCUSSION

Q.20 Have you discussed your radon reading or the booklets with anyone else?

Yes 01 → Go to Q.21

No 02 → Go to Q.22

Q.21 Who did you discuss radon with? DON'T READ THE ITEMS. CIRCLE ALL THAT APPLY. PROBE BY ASKING WAS THERE ANYONE ELSE.

a.	OTHER ADULT MEMBER OF THE HOUSEHOLD	01
b.	CHILDREN	02
c.	RELATIVES OUTSIDE YOUR HOME	03
d.	NEIGHBORS	04
e.	FRIENDS	05
f.	PEOPLE AT WORK	06
g.	CONTRACTORS	07
h.	PUBLIC OFFICIALS	08
i.	STATE AGENCIES	09
j.	FEDERAL AGENCIES	10
k.	TOLL FREE TELEPHONE NUMBER IN THE BROCHURE (NYSERDA OR PROJECT STAFF)	11
l.	OTHER (SPECIFY) ____________________	12
m.	OTHER (SPECIFY) ____________________	13

Q.22 Other than the materials that we sent, have you read or heard anything, or inquired about about radon since we talked with you last summer?

Yes	01 →	Go to Q.23
No	02 →	Go to Q.24
Don't know	94 →	Go to Q.24

Q.23 What was the source of that information? DON'T READ THE ITEMS. PROBE FOR ADDITIONAL SOURCES.

FOR EACH SOURCE MENTIONED, ASK IF WHAT WAS READ OR HEARD WAS BEFORE OR AFTER RECEIVING THE MATERIALS. UNDER THE APPROPRIATE COLUMN, CIRCLE ALL SOURCES THAT APPLY.

		Before	After
a.	READ ONE OF THE SOURCES LISTED IN THE BOOKLET	01	02
b.	READ A MAGAZINE OR NEWSPAPER ARTICLE	01	02
c.	HEARD A TV REPORT ABOUT RADON	01	02
d.	HEARD A RADIO REPORT ABOUT RADON	01	02
e.	ATTENDED A PUBLIC OR NEIGHBORHOOD MEETING	01	02
f.	ASKED A FRIEND OR NEIGHBOR	01	02
g.	ASKED YOUR FAMILY DOCTOR ABOUT RADON	01	02
h.	ASKED UNIVERSITY OR COLLEGE STAFF	01	02
i.	ASKED A GOVERNMENT AGENCY (SPECIFY AGENCY) ________________________	01	02
j.	ASKED A PUBLIC OFFICIAL (SPECIFY WHO) ________________________	01	02
k.	OTHER SOURCE (SPECIFY) ________________________	01	02
l.	NONE OF THE ABOVE	01	02

Q.24 I am going to read a list of ways the State might provide radon information to residents. Tell me if you would be very likely, likely, unlikely, or very unlikely to want information from each of these ways?

	Very Likely	Likely	Un-likely	Very Unlikely	Don't Know
a. A longer booklet containing more detailed information about radon risk	01	02	03	04	94
b. A longer booklet containing more detailed information about how to reduce radon levels	01	02	03	04	94
c. A panel of experts at a city or town meeting	01	02	03	04	94
d. A phone call from a state agency	01	02	03	04	94

Q.25 Suppose a qualified and state licensed person in your area would diagnose how radon was getting into your home. He would also help you decide what to do about it and where to find a qualified contractor. If the full cost of this service was (READ CIRCLED VALUE) $25 $50 $100 $150 $250 $400, would you purchase the service?

Yes	01
No	02
Don't know	94

SECTION VIII: NEW INFORMATION

Q.26 Now, I'd like to ask you about advising a family in your neighborhood on whether to reduce radon levels in their home. Suppose your neighbors were told that their reading for the winter months was (READ CIRCLED NUMBER) 3 4 5 8 10 15 20 30 50 75 picocuries per liter. Would you advise them to reduce their radon levels?

Yes	01 →	Go to Q.27
No	02 →	Go to Q.28
Don't know	94 →	Go to Q.28

Q.27 How soon would you advise them to reduce the levels? READ ITEMS a. THROUGH e.

a.	As soon as possible	01
b.	Within several weeks	02
c.	Within several months	03
d.	Within the next year	04
e.	Within the next few years	05
f.	DON'T KNOW (DON'T READ)	94

SECTION IX: BASELINE QUESTIONS

Q.28 Now, I'd like you to think about different risks you and your household face. For each type of risk that I read, please tell me how serious you think the risk is on a scale from 1 to 10. The number 1 on the scale is not at all serious and 10 is very serious.

		Scale No.
a.	On a 1 to 10 scale, how serious are risks you (and your household) face from auto accidents?	________
b.	On that same 1 to 10 scale, how serious are risks you (and your household) face from home accidents?	________
c.	On that same 1 to 10 scale, how serious are risks you (and your household) face from being exposed to hazardous wastes from factories or landfills?	________
d.	On that same 1 to 10 scale, how serious are risks you (and your household) face from being exposed to radon?	________

Q.29 In general, compared to other health risks people face, how serious a health risk is radon? Use the same 1 to 10 scale. CIRCLE RESPONSE.

1 2 3 4 5 6 7 8 9 10 94

Q.30 Please tell me how strongly you agree or disagree with the following statements about radon risk compared to other types of risk.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
a. The risk of dying from radon is very similar to the risk of dying from floods	01	02	03	04	94
b. The risk of dying from radon is very similar to the risk of dying from chemicals in abandoned hazardous waste sites	01	02	03	04	94
c. The risk of dying from radon is very similar to the risk of dying from a nuclear power plant accident	01	02	03	04	94

Q.31 Are high levels of radon likely to cause (READ LIST)

a. Minor skin problems	01
b. Or lung cancer	02
c. DON'T KNOW (DON'T READ)	94

Q.32 High levels of radon exposure (READ LIST)

a. will irritate the throat and eyes	01
b. or will not irritate the throat and eyes	02
c. DON'T KNOW (DON'T READ)	94

Q.33 When radon is measured indoors, the level (READ LIST)

a.	Will depend on whether the house is closed up	01
b.	Or will not depend on whether the house is closed up	02
c.	DON'T KNOW (DON'T READ)	94

Q.34 Are radon levels usually higher (READ LIST)

a.	In the basement or lowest floor	01
b.	Or on the highest floor	02
c.	DON'T KNOW (DON'T READ)	94

Q.35 Are people's risk from one year of radon exposure (READ LIST)

a.	Much lower than their risk from a lifetime exposure	01
b.	Or about the same as their risk from a lifetime exposure	02
c.	DON'T KNOW (DON'T READ)	94

Q.36 Are household appliances such as furnaces or clothes dryers likely to (READ LIST)

a.	Increase the amount of radon by lowering inside air pressure	01
b.	Or decrease the amount of radon by venting it outside	02
c.	DON'T KNOW (DON'T READ)	94

Q.37 Do you still have questions or concerns about radon? If so, what are they?

____

____

____

THAT'S ALL OF THE QUESTIONS I HAVE. THANK YOU FOR YOUR COOPERATION.

CONTROL FORM FOR THE NEW YORK RADON FOLLOW-UP SURVEY

INTERVIEW START TIME: _______________ STOP TIME: ____________ LTR

AFFIX ASSIGNMENT
LABEL HERE

Remail: Booklets ______ Letter _____ Date __________

RECORD OF TELEPHONE CONTACTS

DAY OF WEEK	DATE	TIME	NOTES	RESULT CODE	TI INITIALS
		A P			
		A P			
		A P			
		A P			
		A P			
		A P			
		A P			
		A P			
		A P			
		A P			

CONTACT RESULT CODES

01 Interview Complete
02 Interview breakoff/partial data
03 Interview Refusal
04 Call back; respondent has not read the materials
05 Call back; respondent unavailable
06 Call back; ring, no answer or busy signal
07 Call back; remail materials
08 Unlisted number
09 Not a working or residential number

SECTION I: INTRODUCTION

Hello, my name is ________________________. I'm calling from Research Triangle Institute in North Carolina. We are conducting the follow-up survey of participants in the State of New York's radon study. I would like to talk with (READ NAME ON THE ASSIGNMENT LABEL), or the person we spoke with early last summer about the radon study.

WHEN YOU ARE TALKING WITH THE PERSON WHO WAS PREVIOUSLY INTERVIEWED, RECORD THAT PERSON'S NAME BELOW.

Respondent's Name: ______________________________________

Q.1 Did you recently receive a letter containing the radon reading for your home? CIRCLE A "YES" OR "NO" RESPONSE.

Yes 01 → Go to Statement 2 below.

No 02 → Go to Statement 1 below.

STATEMENT 1

There must have been a mailing error. I will notify the project leader and have the missing material mailed out to you tomorrow. I'll call again after you've had time to get the material and read it. I want to confirm your name and mailing address.

CONFIRM THE PERSON'S NAME AND MAILING ADDRESS. MAKE NECESSARY CORRECTIONS ON THE ASSIGNMENT LABEL. CHECK WHICH ITEM, BOOKLET OR LETTER, IS TO BE REMAILED. RETURN THIS CASE TO CEER STAFF.

STATEMENT 2

I'd like to ask some questions about the radon material. This should take only a few minutes and your answers will be kept strictly confidential.

Q.2 Did you read the letter and the radon background information page?

Yes 01 → Go to Section 2

No 02 → Go to Statement 3

STATEMENT 3

Since many of my questions are about the letter and information, I need to ask the questions after you have had a chance to read the material. Would this time tomorrow be a good time to call back?

PROBE FOR A CONVENIENT CALLBACK TIME AND RECORD THE TIME IN THE NOTES SECTION ON THE CONTROL PAGE. IF THE RESPONDENT DECLINES TO BE INTERVIEWED, ASK IF ANOTHER ADULT MEMBER OF THE HOUSEHOLD HAS READ THE MATERIALS. ATTEMPT TO INTERVIEW THAT PERSON DURING THIS CALL.

Yes	01	Record callback time
Refused	02	Terminate interview
New Respondent Named	03	Record name of new respondent and attempt to interview

SECTION II: MATERIALS RECEIPT INFORMATION

RECORD THE DATE OF THE INTERVIEW: ___________/___________

Q.4 When did you receive the letter with the radon reading? PROBE FOR APPROXIMATE DATE. USE NUMBERS FOR MONTH. IF RESPONSE IS "LAST WEEK," ASK ABOUT HOW MANY DAYS AGO THE MATERIAL WAS RECEIVED.

Date _______/_______

Don't know 94

Q.5 When did you last read the material? PROBE FOR APPROXIMATE DATE.

Date _______/_______

Don't know 94

Q.6 Altogether, about how long did you spend reading the material? PROBE FOR APPROXIMATE TIME. RECORD TIME IN MINUTES.

Minutes _____________

Don't know 94

SECTION III: RADON INFORMATION EVALUATION

Q.7 The first few questions are about your opinions of the radon background information page. For each statement I read, please tell me how strongly you agree or disagree with it.

	Strongly Agree	Agree	Dis-agree	Strongly Disagree	Don't Know
a. The information page was written in everyday English	01	02	03	04	94
b. The information page was easy to follow	01	02	03	04	94
c. The information page covered what you needed to know	01	02	03	04	94
d. The information made it easy for you to evaluate your risk	01	02	03	04	94
e. The information was consistent with what you had already read about radon	01	02	03	04	94

Q.8 For the next question, I'd like you to think about whether specific radon background information helped or did not help you to understand your radon risk. For each feature I read, tell me if it helped, did not help, or confused you.

	Helped	No Help	Confused	Don't Know
a. Typical levels of radon in the outside air	01	02	03	94
b. The range of indoor radon readings in New York State	01	02	03	94
c. Recommendations on when to take action to reduce your exposure	01	02	03	94

Q.9 Was there anything else about the radon background information that you found to be particularly helpful or confusing?

Helpful:____

Helpful ____

Confusing:______________________________________

Confusing: ______________________________________

SECTION IV: RISK MITIGATION

Q.10 Since receiving your radon reading, have you or anyone in your household done anything, made any plans to do anything, or considered doing anything to reduce your household's exposure to radon?

Yes	01	→ Go to Q.11
No	02	→ Go to Q.12
Don't know	94	→ Go to Q.12

Q.11 Please tell me what has been done, planned, or considered to reduce your household's exposure to radon? DON'T READ ITEMS a. THROUGH q. IF ACTION INVOLVES A TECHNICAL CHANGE OR EQUIPMENT, PROBE FOR ESTIMATED COST.

BEHAVIORAL CHANGES

	Done	Planned	Considered
a. EITHER STOP OR CUT DOWN ON SMOKING INSIDE THE HOME	01	02	03
b. REDUCE THE AMOUNT OF TIME SPENT IN CERTAIN AREAS OF YOUR HOME - FOR EXAMPLE, IN THE BASEMENT	01	02	03
c. OPEN WINDOWS AND TURN ON FANS TO INCREASE AIR FLOW INTO AND THROUGH THE HOUSE	01	02	03
d. ARRANGE FOR MORE RADON TESTS	01	02	03
e. CONTACT A CONTRACTOR	01	02	03
f. OPEN THE CRAWL-SPACE VENTS ON ALL SIDES OF THE HOUSE	01	02	03
g. REVIEW THE MATERIALS AGAIN AND THEN DECIDE WHAT TO DO	01	02	03
h. OTHER (SPECIFY) ______________________	01	02	03

TECHNICAL OR EQUIPMENT CHANGES

	Done	Planned	Considered	Cost
i. INSTALL NATURAL VENTILATION	01	02	03	$________
j. INSTALL FORCED VENTILATION	01	02	03	$________
k. HEAT RECOVERY VENTILATION	01	02	03	$________
l. COVER EXPOSED EARTH	01	02	03	$________
m. SEAL CRACKS AND SPACES	01	02	03	$________
n. INSTALL DRAIN TILE (PIPE) SUCTION	01	02	03	$________
o. INSTALL BLOCK-WALL VENTILATION	01	02	03	$________
p. INSTALL SUB-SLAB SUCTION	01	02	03	$________
q. OTHER (SPECIFY) ______________________	01	02	03	$________

Q.12 Since we talked with you last summer, have you made any of the following major changes to your home? Have you (READ ITEMS a. THROUGH g.). ASK FOR THE APPROXIMATE MONTH EACH CHANGE WAS MADE, AND THE APPROXIMATE COST)

		Yes	No	Don't Know	Month	Cost
a.	Changed your attic insulation	01	02	94	______	$______
b.	Caulked your windows or doors	01	02	94	______	$______
c.	Installed a new furnace or air conditioning system	01	02	94	______	$______
d.	Changed your doors or windows	01	02	94	______	$______
e.	Sealed cracks in your basement	01	02	94	______	$______
f.	Installed an air-to-air heat exchanger	01	02	94	______	$______
g.	Made any other changes (describe)	01	02	94	______	$______

____

____

SECTION V: RADON INFORMATION ACQUISITION AND DISCUSSION

Q.13 Have you discussed your radon reading or the booklets with anyone else?

Yes 01 → Go to Q.14

No 02 → Go to Q.15

Q.14 Who did you discuss radon with? DON'T READ THE ITEMS. CIRCLE ALL THAT APPLY. PROBE BY ASKING WAS THERE ANYONE ELSE.

a.	OTHER ADULT MEMBER OF THE HOUSEHOLD	01
b.	CHILDREN	02
c.	RELATIVES OUTSIDE YOUR HOME	03
d.	NEIGHBORS	04
e.	FRIENDS	05
f.	PEOPLE AT WORK	06
g.	CONTRACTORS	07
h.	PUBLIC OFFICIALS	08
i.	STATE AGENCIES	09
j.	FEDERAL AGENCIES	10
k.	TOLL FREE TELEPHONE NUMBER IN THE BROCHURE (NYSERDA OR PROJECT STAFF)	11
l.	OTHER (SPECIFY) ____________________	12
m.	OTHER (SPECIFY) ____________________	

Q.15 Other than the materials that we sent, have you read or heard anything, or inquired about about radon since we talked with you last summer?

Yes	01 →	Go to Q.16
No	02 →	Go to Q.17
Don't know	94 →	Go to Q.17

Q.16 What was the source of that information? DON'T READ THE ITEMS. PROBE FOR ADDITIONAL SOURCES.

FOR EACH SOURCE MEMTIONED, ASK IF WHAT WAS READ OR HEARD WAS BEFORE OR AFTER RECEIVING THE MATERIALS. UNDER THE APPROPRIATE COLUMN, CIRCLE ALL SOURCES THAT APPLY.

		Before	After
a.	READ ONE OF THE SOURCES LISTED IN THE BOOKLET	01	02
b.	READ A MAGAZINE OR NEWSPAPER ARTICLE	01	02
c.	HEARD A TV REPORT ABOUT RADON	01	02
d.	HEARD A RADIO REPORT ABOUT RADON	01	02
e.	ATTENDED A PUBLIC OR NEIGHBORHOOD MEETING	01	02
f.	ASKED A FRIEND OR NEIGHBOR	01	02
g.	ASKED YOUR FAMILY DOCTOR ABOUT RADON	01	02
h.	ASKED UNIVERSITY OR COLLEGE STAFF	01	02
i.	ASKED A GOVERNMENT AGENCY (SPECIFY AGENCY) ______________________________	01	02
j.	ASKED A PUBLIC OFFICIAL (SPECIFY WHO) ______________________________	01	02
k.	OTHER SOURCE (SPECIFY) ______________________________	01	02
l.	NONE OF THE ABOVE	01	02

Q.17 I am going to read a list of ways the State might provide radon information to residents. Tell me if you would be very likely, likely, unlikely, or very unlikely to want information from each of these ways?

	Very Likely	Likely	Un-likely	Very Unlikely	Don't Know
a. A longer booklet containing more detailed information about radon risk	01	02	03	04	94
b. A longer booklet containing more detailed information about how to reduce radon levels	01	02	03	04	94
c. A panel of experts at a city or town meeting	01	02	03	04	94
d. A phone call from a state agency	01	02	03	04	94

Q.18 Suppose a qualified and state licensed person in your area would diagnose how radon was getting into your home. He would also help you decide what to do about it and where to find a qualified contractor. If the full cost of this service was (READ CIRCLED VALUE) $25 $50 $100 $150 $250 $400, would you purchase the service?

Yes	01
No	02
Don't know	94

SECTION VI: NEW INFORMATION

Q.19 Now, I'd like to ask you about advising a family in your neighborhood on whether to reduce radon levels in their home. Suppose your neighbors were told that their reading for the winter months was (READ CIRCLED NUMBER) 3 4 5 8 10 15 20 30 50 75 picocuries per liter. Would you advise them to reduce the radon levels?

Yes	01 → Go to Q.20
No	02 → Go to Q.21
Don't know	94 → Go to Q.21

Q.20 How soon would you advise them to reduce the levels? READ ITEMS a. THROUGH e.

a.	As soon as possible	01
b.	Within several weeks	02
c.	Within several months	03
d.	Within the next year	04
e.	Within the next few years	05
f.	DON'T KNOW (DON'T READ)	94

SECTION VII: BASELINE QUESTIONS

Q.21 Now, I'd like you to think about different risks you and your household face. For each type of risk that I read, please tell me how serious you think the risk is on a scale from 1 to 10. The number 1 on the scale is not at all serious and 10 is very serious.

		Scale No.
a.	On a 1 to 10 scale, how serious are risks you (and your household) face from auto accidents?	________
b.	On that same 1 to 10 scale, how serious are risks you (and your household) face from home accidents?	________
c.	On that same 1 to 10 scale, how serious are risks you (and your household) face from being exposed to hazardous wastes from factories or landfills?	________
d.	On that same 1 to 10 scale, how serious are risks you (and your household) face from being exposed to radon?	________

Q.22 In general, compared to other health risks people face, how serious a health risk is radon? Use the same 1 to 10 scale. CIRCLE RESPONSE.

1 2 3 4 5 6 7 8 9 10 94

Q.23 Please tell me how strongly you agree or disagree with the following statements about radon risk compared to other types of risk.

	Strongly Agree	Agree	Disagree	Strongly Disagree	Don't Know
a. The risk of dying from radon is very similar to the risk of dying from floods	01	02	03	04	94
b. The risk of dying from radon is very similar to the risk of dying from chemicals in abandoned hazardous waste sites	01	02	03	04	94
c. The risk of dying from radon is very similar to the risk of dying from a nuclear power plant accident	01	02	03	04	94

Q.24 Are high levels of radon likely to cause (READ LIST)

a. Minor skin problems	01
b. Or lung cancer	02
c. DON'T KNOW (DON'T READ)	94

Q.25 High levels of radon exposure (READ LIST)

a. will irritate the throat and eyes	01
b. or will not irritate the throat and eyes	02
c. DON'T KNOW (DON'T READ)	94

Q.26 When radon is measured indoors, the level (READ LIST)

a.	Will depend on whether the house is closed up	01
b.	Or will not depend on whether the house is closed up	02
c.	DON'T KNOW (DON'T READ)	94

Q.27 Are radon levels usually higher (READ LIST)

a.	In the basement or lowest floor	01
b.	Or on the highest floor	02
c.	DON'T KNOW (DON'T READ)	94

Q.28 Are people's risk from one year of radon exposure (READ LIST)

a.	Much lower than their risk from a lifetime exposure	01
b.	Or about the same as their risk from a lifetime exposure	02
c.	DON'T KNOW (DON'T READ)	94

Q.29 Are household appliances such as furnaces or clothes dryers likely to (READ LIST)

a.	Increase the amount of radon by lowering inside air pressure	01
b.	Or decrease the amount of radon by venting it outside	02
c.	DON'T KNOW (DON'T READ)	94

Q.30 Do you still have questions or concerns about radon? If so, what are they?

____

____

____

THAT'S ALL OF THE QUESTIONS I HAVE. THANK YOU FOR YOUR COOPERATION.

CONTROL FORM FOR THE NEW YORK RADON COMPARISON GROUP FOLLOWUP SURVEY

INTERVIEW START TIME: ______________ STOP TIME: ____________ NYSERD

AFFIX ASSIGNMENT
LABEL HERE

RECORD OF TELEPHONE CONTACTS

DAY OF WEEK	DATE	TIME	NOTES	RESULT CODE	TI INITIALS
		A P			
		A P			
		A P			
		A P			
		A P			
		A P			
		A P			
		A P			
		A P			
		A P			

CONTACT RESULT CODES

01 Interview Complete
02 Interview breakoff/partial data
03 Interview Refusal
04 Call back; respondent has not read the materials
05 Call back; respondent unavailable
06 Call back; ring, no answer or busy signal
07 Call back; remail materials
08 Unlisted number
09 Not a working or residential number

RADON INFORMATION EFFECTIVENESS SURVEY: COMPARISON GROUP FOLLOWUP QUESTIONNAIRE

Hello, my name is ______________________. I'm calling from Research Triangle Institute in North Carolina. We are conducting a followup survey of what people know and think about radon. I would like to talk with (READ NAME ON THE ASSIGNMENT LABEL) or the person we spoke with early last summer about radon.

WHEN YOU ARE TALKING WITH THE PERSON WHO WAS PREVIOUSLY INTERVIEWED, RECORD THAT PERSON'S NAME BELOW.

Respondent's Name: ______________________

SECTION I: RADON KNOWLEDGE

I am going to ask some multiple choice questions about radon. Please choose the answer you think is correct or answer "I don't know" if that's your best answer.

1. Is radon a

	Record Responses
a. Colorless, odorless gas	01
b. Or a chemical given off by radar equipment	02
c. Don't know (DON'T READ)	94

2. Is radon caused by

a. Industrial pollution	01
b. Or the natural breakdown of uranium	02
c. Don't know (DON'T READ)	94

3. Are high levels of radon likely to cause

a. Minor skin problems	01
b. Or lung cancer	02
c. Don't know (DON'T READ)	94

4. High levels of radon exposure (READ LIST)

a. Will irritate the throat and eyes	01
b. Or will not irritate the throat and eyes	02
c. Don't know (DON'T READ)	94

5. When radon is measured indoors, the level (READ LIST)

   a. Will depend on whether the house is closed up................ 01
   depend on whether the house is closed up......... 02
   c. Don't know (DON'T READ)....................................... 94

6. Are radon levels usually higher in

   a. The basement or lowest floor................................. 01
   b. Or the highest floor... 02
   c. Don't know (DON'T READ)...................................... 94

7. Are people's risk from 1 year of radon exposure (READ LIST)

   a. Much lower than their risk from a lifetime exposure.......... 01
   b. Or about the same as their risk from a lifetime exposure..... 02
   c. Don't know (DON'T READ)...................................... 94

8. Are household appliances such as furnaces or clothes dryers likely to

   a. Increase the amount of radon by lowering inside air pressure... 01
   b. Or decrease the amount of radon by venting it outside........ 02
   c. Don't know (DON'T READ)...................................... 94

Now I'd like to ask you a few questions about any information you may have read or heard about radon.

9. During the past 3 months, have you read or heard anything about radon?

   Yes...................... 01
   No....................... 02 → (Go to Q.12)

10. About how many times during the last 3 months have you read or heard anything about radon?

   __________ (RECORD NUMBER)

11. Some people may have done more than others to find out about radon. Have you ever . . . (READ LIST)

	Yes	No	Don't know
a. Bought a newspaper or a magazine specifically to read something about radon?..........................	01	02	94
b. Tuned into a television or a radio program specifically to learn about radon?..................	01	02	94
c. Obtained information from a library about radon?.....	01	02	94
d. Contacted a federal, state, or local government agency to get information about radon?...............	01	02	94
e. Attended a public or neighborhood meeting about radon?..	01	02	94
f. Discussed radon with friends and relatives?..........	01	02	94
g. Done anything else that I haven't mentioned to obtain information about radon? (IF YES, ASK: What was that?) (RECORD ANSWERS BELOW)...............	01	02	94

12. Suppose a qualified and state licened person in your area would diagnose how radon was getting into your home. He would also help you decide what to do about it and where to find a qualified contractor. If the full cost of this service was (READ CIRCLED VALUE) $25 $50 $100 $150 $250 $400, would you purchase the service?

Yes..................... 01
No...................... 02
Don't know.............. 94

13. Now, I'd like to ask you about advising a family in your neighborhood on whether to reduce radon levels in their home. Suppose your neighbors were told that their reading for the winter months was (READ CIRCLED NUMBER) 3 4 5 8 10 15 20 30 50 75 picocuries per liter. Would you advise them to reduce their radon levels?

Yes..................... 01 → Go to Q.14
No...................... 02 → Go to Q.15
Don't know.............. 94 → Go to Q.15

14. How soon would you advise them to reduce the levels? READ ITEMS a THROUGH f.

a.	As soon as possible..............	01
b.	Within several weeks.............	02
c.	Within several months............	03
d.	Within the next year.............	04
e.	Within the next few years........	05
f.	Don't know (DON'T READ)..........	94

SECTION II: RADON RISK INFORMATION

15. Now, I'd like you to think about different risks you and your household face. For each type of risk that I read, please tell me how serious you think the risk is on a scale from 1 to 10. Number 1 on the scale is not at all serious and 10 is very serious.

	Scale No.
a. On a 1 to 10 scale, how serious are risks you (and your household) face from auto accidents?	______
b. On that same 1 to 10 scale, how serious are risks you (and your household) face from home accidents?	______
c. On that same 1 to 10 scale, how serious are risks you (and your household) face from being exposed to hazardous wastes from factories or landfills?	______
d. On that same 1 to 10 scale, how serious are risks you (and your household) face from being exposed to radon?	______

16. Compared to other health risks people face, how serious a health risk is radon--on a scale from 1 to 10 with 1 being not at all serious and 10 being very serious.

(RECORD RESPONSE AND PROBE FOR RANGE OR NUMBER.) ________

17. I am going to read a list of ways the state might provide radon information to residents. Tell me if you would be very likely, likely, unlikely, or very unlikely to want information from each of these ways?

	Very likely	Likely	Un-likely	Very unlikely	Don't know
a. A longer booklet containing more detailed information about radon risk	01	02	03	04	94
b. A longer booklet containing more detailed information about how to reduce radon levels	01	02	03	04	94
c. A panel of experts at a city or town meeting	01	02	03	04	94
d. A phone call from a state agency	01	02	03	04	94

TERMINATION

Thank you very much for your cooperation. Your answers will be most helpful in this study.

RADON INFORMATION EFFECTIVENESS SURVEY:
COMPARISON GROUP FOLLOWUP QUESTIONNAIRE

Hello, my name is ________________________. I'm calling from Research Triangle Institute in North Carolina. We are conducting a followup survey of what people know and think about radon. I would like to talk with (READ NAME ON THE ASSIGNMENT LABEL) or the person we spoke with early last summer about radon.

WHEN YOU ARE TALKING WITH THE PERSON WHO WAS PREVIOUSLY INTERVIEWED, RECORD THAT PERSON'S NAME BELOW.

Respondent's Name: ____________________________

SECTION I: RADON KNOWLEDGE

I am going to ask some multiple choice questions about radon. Please choose the answer you think is correct or answer "I don't know" if that's your best answer.

	Record Responses
1. Is radon a	
a. Colorless, odorless gas	01
b. Or a chemical given off by radar equipment	02
c. Don't know (DON'T READ)	94
2. Is radon caused by	
a. Industrial pollution	01
b. Or the natural breakdown of uranium	02
c. Don't know (DON'T READ)	94
3. Are high levels of radon likely to cause	
a. Minor skin problems	01
b. Or lung cancer	02
c. Don't know (DON'T READ)	94
4. High levels of radon exposure (READ LIST)	
a. Will irritate the throat and eyes	01
b. Or will not irritate the throat and eyes	02
c. Don't know (DON'T READ)	94

5. When radon is measured indoors, the level (READ LIST)

  a. Will depend on whether the house is closed up................ 01
  [illegible] depend on whether the house is closed up......... 02
  c. Don't know (DON'T READ)...................................... 94

6. Are radon levels usually higher in

  a. The basement or lowest floor.................................. 01
  b. Or the highest floor... 02
  c. Don't know (DON'T READ)...................................... 94

7. Are people's risk from 1 year of radon exposure (READ LIST)

  a. Much lower than their risk from a lifetime exposure.......... 01
  b. Or about the same as their risk from a lifetime exposure..... 02
  c. Don't know (DON'T READ)...................................... 94

8. Are household appliances such as furnaces or clothes dryers likely to

  a. Increase the amount of radon by lowering inside air pressure.. 01
  b. Or decrease the amount of radon by venting it outside........ 02
  c. Don't know (DON'T READ)...................................... 94

Now I'd like to ask you a few questions about any information you may have read or heard about radon.

9. During the past 3 months, have you read or heard anything about radon?

  Yes...................... 01
  No....................... 02 → (Go to Q.12)

10. About how many times during the last 3 months have you read or heard anything about radon?

  __________ (RECORD NUMBER)

11. Some people may have done more than others to find out about radon. Have you ever . . . (READ LIST)

		Yes	No	Don't know
a.	Bought a newspaper or a magazine specifically to read something about radon?..........................	01	02	94
b.	Tuned into a television or a radio program specifically to learn about radon?..................	01	02	94
c.	Obtained information from a library about radon?.....	01	02	94
d.	Contacted a federal, state, or local government agency to get information about radon?..............	01	02	94
e.	Attended a public or neighborhood meeting about radon?...	01	02	94
f.	Discussed radon with friends and relatives?..........	01	02	94
g.	Done anything else that I haven't mentioned to obtain information about radon? (IF YES, ASK: What was that?) (RECORD ANSWERS BELOW)..............	01	02	94

____

____

12. Suppose a qualified and state licened person in your area would diagnose how radon was getting into your home. He would also help you decide what to do about it and where to find a qualified contractor. If the full cost of this service was (READ CIRCLED VALUE) $25 $50 $100 $150 $250 $400, would you purchase the service?

Yes...................... 01
No....................... 02
Don't know............... 94

13. Now, I'd like to ask you about advising a family in your neighborhood on whether to reduce radon levels in their home. Suppose your neighbors were told that their reading for the winter months was (READ CIRCLED NUMBER) 3 4 5 8 10 15 20 30 50 75 picocuries per liter. Would you advise them to reduce their radon levels?

Yes...................... 01 → Go to Q.14
No....................... 02 → Go to Q.15
Don't know............... 94 → Go to Q.15

14. How soon would you advise them to reduce the levels? READ ITEMS a THROUGH f.

a.	As soon as possible..............	01
b.	Within several weeks.............	02
c.	Within several months............	03
d.	Within the next year.............	04
e.	Within the next few years........	05
f.	Don't know (DON'T READ)..........	94

SECTION II: RADON RISK INFORMATION

15. Now, I'd like you to think about different risks you and your household face. For each type of risk that I read, please tell me how serious you think the risk is on a scale from 1 to 10. Number 1 on the scale is not at all serious and 10 is very serious.

	Scale No.
a. On a 1 to 10 scale, how serious are risks you (and your household) face from auto accidents?	________
b. On that same 1 to 10 scale, how serious are risks you (and your household) face from home accidents?	________
c. On that same 1 to 10 scale, how serious are risks you (and your household) face from being exposed to hazardous wastes from factories or landfills?	________
d. On that same 1 to 10 scale, how serious are risks you (and your household) face from being exposed to radon?	________

16. Compared to other health risks people face, how serious a health risk is radon--on a scale from 1 to 10 with 1 being not at all serious and 10 being very serious.

(RECORD RESPONSE AND PROBE FOR RANGE OR NUMBER.) ___________

17. I am going to read a list of ways the state might provide radon information to residents. Tell me if you would be very likely, likely, unlikely, or very unlikely to want information from each of these ways?

	Very likely	Likely	Un-likely	Very unlikely	Don't know
a. A longer booklet containing more detailed information about radon risk	01	02	03	04	94
b. A longer booklet containing more detailed information about how to reduce radon levels	01	02	03	04	94
c. A panel of experts at a city or town meeting	01	02	03	04	94
d. A phone call from a state agency	01	02	03	04	94

TERMINATION

Thank you very much for your cooperation. Your answers will be most helpful in this study.